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The Engineer's Manual of English

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REVISED EDITION

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Preface to the Revised Edition

THE MAIN FEATURES of the revised edition of *The Engineer's Manual of English* are

1. The abandonment of the division of the book into two parts—the specimens, constituting Part II of the former book, now being integrated directly with the discussions of the respective kinds of technical writing.

2 A strengthening of the chapters on Correspondence and Report Writing, with the particular aim of making both discussion and illustrations more helpful to the engineering student who in college is asked to do these kinds of writing. The student themes, which appear here in more abundance than in the earlier edition, should provide specific suggestions for the prospective engineer's practice work in writing.

3 The selection of current specimens of the various kinds of technical writing to replace similar material which, even though just as good for the specific purpose, may have lost through the passing of time its appeal of freshness or immediacy. The retention of some illustrative material from the earlier edition is justified, in the opinion of the authors of the book, on the ground of particular effectiveness.

4 A complete revision of Chapter 1, involving the removal to a separate chapter (Chapter 2) of the sections on paragraphs, sentences, and words. These sections have been greatly expanded in the new treatment.

5 In the chapter on Writing for Technical Journals, a revision, or the introduction, of the discussions on Definitions, Brief Explanations, Abstracts or Summaries, and Technical Articles, to which are attached appropriate illustrative specimens.

6 The addition of an Appendix on Military Communications and an Appendix on Public Speaking.

For Chapters 1 and 2 Professor Fountain has been primarily responsible; for the revision of the remaining chapters and for the appendices, Professor Sypherd.

In the preparation of this revised edition the authors have profited greatly by the suggestions for improvement which have

been offered so generously by users of the earlier book, notably, Professors Fred W. Ajax of the Georgia School of Technology, George Montgomery of the Drexel Institute, E. J. Nichols of Pennsylvania State, W. F. Scamman of the University of Maine, S. Marion Tucker of the Polytechnic Institute of Brooklyn, K. C. White of Cornell, George S. Wykoff of Purdue, and John B. O'Farrell of the College of the City of New York.

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From engineers in the practical world of engineering we have received many suggestions and much illustrative material which together have contributed vitally toward the making of what we believe is an authoritative book. We are particularly grateful to Dr. D. P. Barnard of the Standard Oil Company, G. R. Cantwell and Dr. James K. Hunt of E. I. duPont de Nemours and Company, T. S. Carswell of the Monsanto Chemical Company, A. F. E. Horn of the General Electric Company, Victor H. Jones of the Philadelphia Electric Company, F. H. McEnanem and W. T. Manning of the Westinghouse Electric and Manufacturing Company, John Mills of the Bell Telephone Laboratories, Terry Mitchell of the Frick Company, J. A. Onarheim of the Allis-Chalmers Manufacturing Company, Arvid Roach of the General Motors Company, W. A. Sawdon of *The Petroleum Engineer*, E. F. Mullin of the Link-Belt Company, and Messrs. T. E. Seelye, Henry E. Ehlers, W. E. Leonard, and W. A. Hemphill of the Day and Zimmermann Company.

Our indebtedness to publishers of technical journals and books and to authors of books and articles who have so kindly allowed us to reproduce material in this book is very great. Specific acknowledgment of such indebtedness is made in connection with the articles here reprinted.

W. O. S.
A. M. F.

April, 1943

Preface to the 1933 Edition

THIS MANUAL has been designed to serve (1) as a textbook in English composition for college students in engineering; (2) as a reference book on usage in technical writing for practicing engineers.

Under the first head it aims less to teach the principles of formal rhetoric, already available in a sufficient number of textbooks, than to show the application of these principles to the actual problems of the engineer-writer. Notwithstanding this major purpose, the authors have, in the first chapter, taken a broad view of the technic which underlies good writing of whatever nature; and in the second chapter have treated such generally applicable details of composition as punctuation, abbreviations, and so forth. The remaining chapters of Part I treat those forms of writing with which engineers are concerned: correspondence, reports, articles for technical journals, bulletins, catalogues, and specifications. Throughout Part I the nature of the discussion and the selection of illustrations have been dictated by the desire to produce not an English Manual for engineers but an *Engineer's* Manual of English. In other words, this book is for the engineer-writer, graduate or undergraduate, and for him alone. It is written in his language, it deals with the concerns of his profession, it interprets the art of communication from his particular "slant."

In addition to being a handbook of usage in technical writing, this Manual is also, in Part II, a book of specimens. With the exception of examples of correspondence, the longer illustrations of the text are presented in Part II, partly as models for analysis and imitation, partly as readings in engineering literature. Although they are not, of course, to be slavishly copied, they contain large possibilities for profitable study and discussion.

In the treatment of abbreviations, the authors have adopted the rules and practice which have been tentatively suggested by the American Standards Association. Absolute uniformity and consistency in the use of abbreviations are not at present attainable, but these new suggestions with their stress on compact and

economical expression seem to point the way toward a more nearly uniform and rational system of abbreviation of technical terms. The omission of the period after abbreviations of technical terms, except where confusion might result, should logically extend to abbreviations of words in general use, and we have therefore, as far as has seemed practicable, omitted periods after such abbreviations.

For permission to print specimens of the several kinds of technical writing, the authors are greatly indebted to engineers, manufacturers, and publishers. Suitable acknowledgment of indebtedness is made in connection with the articles reprinted.

To Professor Lindsay Todd Damon, who, with sharply scrutinizing eye and pertinently questioning mind, has followed the course of the first writing and subsequent revision, we wish to record our deep gratitude. We hope that he will derive some satisfaction from the completed book, in which he will certainly now and then detect evidences of the suggestions of a wise and sympathetic critic.

W. O. S.

S. B.

April, 1933

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CHAPTER 1

General Problems

THE ENGINEER is a master of tools. By his instruments of precision and his methods of calculation, he arrives at results far beyond the ability of the untrained hand or the unaided eye. Even his imagination is guided by these instruments and methods. He sees clearly the functional symmetry or the effective dynamic of his product long before any part reaches material form. His tools thus become instruments more closely identified with intelligence than with manipulation.

It is not strange, then, that the engineer should regard his language as one of his tools. Through language he gains the results of others' experiences; but, more important, through it he brings to others his own experiences. His ability to marshal and present his ideas efficiently adds greatly to his professional effectiveness. He is rightfully proud of the accuracy with which he uses his other tools; he should be no less proud and painstaking in his use of words.

The engineer has for his writings many specialized forms, and uses a vocabulary as intricate as his profession. His problem of expression, however, is basically the same as that of any other person who wishes to convey ideas on paper. He must exercise the same care in his choice of words, his sentence construction, his paragraph building, and his arrangement of the elements of his whole discussion.

Indeed, he must be even more painstaking in the accuracy and force of his writing, since he does not employ the several literary devices freely used by authors whose purpose is merely to entertain. The poet, the novelist, and even the popular feature writer may enliven their writings by figurative language, dramatic incident, or personal bias; the engineer must usually limit himself to a straightforward discussion that makes clear his ideas with the least possible reader-effort. Most of the engineer's

writing is not read for entertainment or viewed as art. It is rather examined, as would be a specimen cabinet, with its exhibits properly identified, classified, and pigeonholed. The engineer's writing is objective and impersonal. By the very absence of *I*, *we*, and *you*, it testifies that its findings are the same as those of any other competent observer, disinterestedly obtaining and transferring information.

Such rigorous requirements explain the plea, universal among executives, that engineering students be taught the basic principles of good English composition, whether or not they have drill in any specialized forms of technical discourse. Clearly, such requirements make it necessary that the student of technical writing be thoroughly grounded in parts of speech and grammatical relationships. Those not so grounded would do well to make further study of composition, or at least to have constantly available a handbook of English usage. The aim of the present text is not to discuss these fundamentals as such, but rather to apply them to the writing tasks of the engineer. Chapters 2 and 3, however, provide a review of the fundamentals. Later portions of the book will examine several of the forms of technical writing; the first chapter is limited to the more general problems of collecting information and putting it into that order and language best suited to the purpose for which it was assembled.

Objectivity in Technical Writing

The engineer is becoming more and more conscious of his social responsibility. He is no longer the recluse of the laboratory nor the blunt-speaking surveyor of the frontier. He is constantly called upon to explain his work to audiences and readers with widely varied training in the sciences. At times he must write articles in purely popular language, plentifully leavened with personal incident and humanizing detail. Other portions of this text discuss and illustrate many of these popular adaptations of technical information.

But in his purely technical papers, the engineer's impersonal and unbiased evaluation of his problems must be reflected in his language. The physician, and still more the minister, must deal with problems essentially personal and emotional, and they are thus privileged to draw upon the resources of their own individualities in solving those problems. The engineer must

submerge his own opinions and feelings in the certainty and accuracy of his findings.

Accordingly, almost all of his technical writing must be presented in the third person. Any lapse from this rule automatically leads the reader to believe that the statements of the engineer have been colored by subjective reasoning. On the other hand, a strict observance of the third-person attitude not only adds dignity to the expression but also instills in the reader a respect for the statements and recommendations of the engineer. Moreover, the use of the third person has a most wholesome effect on the writer; subconsciously, he looks more closely to his own accuracy, and watches that his *opinions* are not *opinionations*.

Of course, the constant use of the third person brings difficulties. Unless care is taken, it may cause the language to seem stilted and mechanical. It may encourage short, choppy sentences, lacking in variety. It almost surely will bring an excessive use of the passive voice, which is usually regarded as a weaker form, and of dangling modifiers of one sort or another. Worst of all, it may lack the freshness and vigor which should be qualities of all technical writing.

But all these difficulties may be avoided or overcome by proper use of varied vocabulary, sharp phrasing, and disciplined sentence structure. Though he is limited to the third person, the technical writer has at hand most of the resources of expression available to others, and he should make those resources work for him. He should not mistake rules for regimentation but should utilize vigorous expression within the limitations he has to observe. A major portion of the present text undertakes to make easier for him the application of sound rhetorical principles within those limitations.

Adaptation to Reader

Inherent in the impersonal attitude of the engineer is the realization that the reader is not only another person, but also a particular kind of person, with definite limits of technical knowledge, experience, and interest. The engineer should remember that his reader is a person subject to the very human traits of habit and prejudice, yet one who likes to feel that an appeal is directed to his intelligence and dignity.

The technical writer, then, must fit his writings to the

reader. He would not use in a report to city aldermen the same language he would employ in a paper to be presented to a society of engineers; he would not follow before a group of investors the same organization or style he would use in a feature article for informing the readers of a local paper. Always he must bear in mind that no audience or reader-group will exert itself to understand material beyond the easy grasp of everyday experience. For technically trained readers, the writer must concentrate on scientifically accurate discussion, using the language and the organization which convey the most information in the shortest space. For the non-technical reader, he must exclude complicated detail and if possible include human interest and dramatic portrayal. Groups intermediate in training will require intermediate gradations of complication and detail.

Space here limits the illustrations, but the following brief examples give some indication of the wording and choice of materials for readers with different degrees of technical training and professional interest. A magazine edited for popular reading would be careful to emphasize the human-interest values in a technical article, at the same time enlivening the language by human touches, and keeping the vocabulary well within the comprehension of the average educated layman. A good example is this discussion of atomic disintegration as a source of energy.

> The rate of isolating U-235 is one ten-billionth of a pound per hour. It is generally agreed that at least a pound would be needed for practical power experiments. By this method a pound would take about 11,000 centuries to produce.
>
> Last week, however, word came from Stockholm that a Swedish scientist had been building thermal diffusion tubes expected to speed up U-235 production 11,000 times, when he was stopped by the war raging around his beleaguered country. In the U.S., Gano Dunn, president of J. G. White Engineering Corp., predicted that atomic power would be available in 20 years, maybe ten. Mr. Dunn, a practical man who personally holds more than 30 patents, said he was sure that Robert Andrews Millikan would agree with him. Dr. Millikan, Caltech's famed cosmic-ray authority who used to say that atomic power was a visionary dream, was "unavailable" to reporters who wanted to know whether he agreed or not. As a friend of Mr. Dunn's he may possibly not have wanted to contradict him.[1]

[1] "Atomic Power in Ten Years," *Time*, May 27, 1940, p. 46

A scientific journal, even though edited for the general reader, would tend to eliminate emphasis on personalities and would enter into a fuller discussion of the scientific principles involved. At the same time, it would use illustrations from common experience, and employ language intelligible to the ordinary person with a scientific turn of mind. A good example is the following discussion of the subject taken up in the preceding quotation. The different method of portrayal is quite evident.

> What happens in the bombardment is that slow neutrons crack U-235 atoms as a baseball bat would crack a walnut, splitting them in two. Accompanying the explosion is a terrific release of energy. Particularly significant is the fact that, in a quantity of U-235, the process is cumulative, for the smash sets free other neutrons, which in turn attack other atoms. Once begun, the process will continue automatically—a "chain of reaction."
>
> When natural uranium was first bombarded, the explosions did not continue in this fashion because of the great preponderance of U-238. The stray neutrons which would keep the action going in pure U-235 collided with atoms of U-238 which are unaffected by the slow barrage that shatters U-235. Consequently, there was an effect of smothering. Even with pure U-235, a considerable amount would be required, for many of the neutrons fly off harmlessly into the air. . . .
>
> Dr. Nier estimates that, even with any reasonably economical means of extracting U-235 in large quantities, the cost per unit of energy produced would equal that of coal.[2]

Still, the discussions have in no wise emphasized any practical applications of the scientific principle. It remains for a workaday journal of industrial installation and operation to search out and discuss these possibilities in the language of the budget-minded plant operator. In order to make its discussion most telling, such a journal would use the units of measure, the abbreviations, and the illustrations common to its readers. An excellent example is the following discussion, also about atomic power.

> Energy is released in the splitting which for U-235 amounts to 31,000,000,000 Btu per pound or equivalent to 1300 tons of coal,

[2] R. H. Copperud, "Is Atomic Energy Nearer?" *Scientific American*, July, 1940, p. 16

> and by placing U-235 in water the process can be controlled, and the heat can be utilized to generate steam. This is the theory, which sounds simple. But nobody has been able to test it out because there is no amount of U-235 sufficient for tests. Dr. Nier ran his experiment 24 hr a day for 10 days to get 1036 millionths of a gram, at which rate it would take 11,995,074 yr to get 1 lb.
>
> Professor W. Krasny-Ergen of University of Stockholm was last year building apparatus which was expected to produce U-235 at the rate of 1 lb in 960 yr, evidently not yet mass production, but invasion of Norway stopped the work. If successful, the multiple use of 100,000 units could produce 1 lb in 4 days, but this is purely speculation. Production of U-235 in quantity may be possible in 10 yr, or not for generations, or never. As 1 lb has explosive power equal to 15,000 tons of TNT, it is to be hoped that methods of handling and control will be developed before any considerable amount is available. At any rate, it is not likely to be available as a cheap source of power for many years, as cost of production is likely to be prohibitive.[3]

It should be noted too that in the example above, the further practical problems of safety are for the first time considered. One may also observe that in the practical journal less care is given to phraseology and sentence structure.

For the completely theoretical journal, composed largely of papers presented to scientific societies, the writer is not concerned with limitations of comprehension or with possibilities of profitable adaptation. His readers or hearers are those who, by training, interest, and experience, are quite capable of understanding the complications of both the discovery and the language necessary to discuss it. With all the freedom of these conditions, the technical writer is able to enter fully into his discussion, and to make the process clear to his readers, or even repeatable in their own laboratories.

A good example of such writing is the following excerpt, taken from a paper originally presented to a group of scientists in national convention, and later published in their journal.

> Several hundreds of different artificial nuclear disintegrations have now been investigated. Their study has led to the development of the so-called nuclear chemistry, in which, instead of changes of aggregations of atoms to form different molecules, as in

[3] "U-235," *Power Plant Engineering*, March, 1941, p. 134

> chemistry, changes in the aggregations of neutrons and protons to form different nuclei are observed. . . .
>
> Nuclei have been bombarded so far mostly with the following types of projectiles: alpha particles, protons, deuterons, and neutrons. Whenever one of these particles strikes the nucleus it is incorporated into the nuclear structure, and another particle may be emitted which belongs to one of the same four types. In a few instances nuclear reactions have been produced by hard gamma rays or by high-energy electrons. . . .
>
> A pictorial image of the process has been suggested by Bohr, who compared this process with what happens when a liquid drop divides into two smaller droplets as a consequence of a very strong oscillation in which it changes from the original spherical form into an elongated shape. In the case of uranium, however, as soon as the two fragments are separated and the cohesive forces cease to attract them, the strong repulsion due to both fragments being positively charged pushes them apart, impressing on them a relatively enormous kinetic energy. . . .[4]

Although each of the foregoing examples is written by a different person, any one of them could be duplicated by a qualified technical writer. In fact, often one person must write material in all these styles. It is necessary only that he keep his language and his illustrations within the range of his readers.

Of course, adaptation means more than mere gradations of technical difficulty. Technical information should be conveyed in the language and the utilities of the group to whom the writing is addressed. A paper on nylon, for example, would be written in very different styles for a textile journal, a woman's magazine, a house organ of a tire company, and a journal of chemistry. Each journal would emphasize the processes, the values, and the illustrations most directly of interest to the group addressed. No purpose is served in any technical article which puts emphasis upon aspects not related to the reader.

Steps in Preparation

For discussions of larger scope, the problems of preparation and organization are vastly important. The writer must be sure of his own knowledge of the subject, and must be doubly sure of his method of presenting his material to the readers. A

[4] E. Fermi, "Nuclear Disintegration," *Electrical Engineering*, February, 1940, pp. 57-58

strong connection exists between the two. The reader quickly senses the writer's qualifications, as much from the organization as from the content of the discussion.

The technical writer must always be careful of his arrangement, his organization, even in brief reports, letters, or other short communications and discussions. Little study or outlining is necessary here, however. The few divisions of the simple material fall naturally and easily into place, and the reader has little difficulty in grasping the significance of the information conveyed.

First-hand reports. Problems the engineer has been able to examine at first hand require little library research, unless the writer wishes to make a study of similar projects for comparison with the one under immediate discussion. His chief source of material and organization is his own knowledge of the subject and his experienced insight into the best arrangement of its portrayal. Methods of writing the report, whether it is based on first-hand observations or research or both, are discussed at length in Chapter 5. A brief view of the process of developing the first-hand report is presented here, however, to complete the student's orientation.

In formal first-hand reports, the arrangement of parts must be guided by the purpose for which the report is intended. The purpose, in turn, must always be formulated on the basis of the needs of the employer or client for whom the report is prepared. The client states his wishes in any of several manners, usually including conversation and questions, analysis of the problem, letter of instruction (or authority), and formal agreement on methods of procedure. The first step in the preparation of a technical report, then, is a complete meeting of minds between the investigator and his client.

The next part of the preparation is entirely the responsibility of the consultant. He alone must formulate his method of attack and procedure. He must pick out the materials of significance to the client. Usually he is able to map out his plans by comparing his particular problem to a similar situation he has met in the past. If he has had no similar reports in the past, he may consult the reports which other investigators have made on like problems.

Articles involving research. Most if not the majority of the discussions you will have to develop will involve a survey of material already in print. In all such instances, most careful note-

taking and note-arranging are necessary. A few minutes spent in proper recording of material and sources will save hours later in the preparation of a technical paper.

Use of indexes. Barely a generation ago, library research was largely a problem of endless toil and hit-or-miss results. Now, with dozens of indexes, and hundreds of guides, listings, and bibliographies at his disposal, the engineer has little difficulty in finding any book or article which he cares to examine. Indeed, his problem has become not so much one of groping until he blunders into usable material as one of learning to use efficiently the *machinery* of library research.

Having so many aids at hand, however, the technical man is expected to know what has been written on his topic before he undertakes further discussion of it. His professional reputation and his own self-confidence would suffer from an innocent discussion of some technical problem which had been treated adequately in preceding papers. Besides, the engineer's own development depends upon his ability to learn and profit by the experience of others.

Of the larger problems of book lists, catalog systems, and the like, it is presumed that the technical student is already sufficiently informed. For him it is more immediately important to know something of the particular indexes most valuable to him, to know the form and kind of information they give, and to know the accepted methods of documenting any discussion which he may draw from the writings of others.

The card catalog of larger libraries, both public and academic, is the master index to all the materials available in any one collection. The cabinets and drawers of filing cards are familiar to every graduate and undergraduate; yet the average student in the use of this index has barely begun to draw upon the total information which it can give. Consequently, a first duty of the technical student should be to acquaint himself further with the card catalog in order that he may use it as a guide to a more intelligent selection and use of printed source materials.

Though ancient libraries of necessity had some kind of classification, and though public and private collections have through the ages made some kind of system for arranging and listing their books, it is only within the last three quarters of a century that contemporary systems of cataloguing have come into existence, at least in America.

Tabulation Showing Qualities of Different Library Classifications[5]

Author and Method	Basis of Notation	Scheme	Logicality	Mnemonics	Nomenclature	Index
James Duff Brown Subject Classification	Letters	11 main classes	Scientific progress on each class	Categorical tables in each subject	Modern	Special index of categories
Cutter Expansive Classification	Letters	26 large classes (Biography separate or with classes)	Entirely logical	Figures for form and local divisions	Modern	No general index
Melvil Dewey Decimal Classification	Numbers	10 classes (Biography preferably separated)	Somewhat lacking	Form divisions	Obsolete	Complete relative index
Library of Congress Classification	Letters and figures used in blocks to expand topics	21 classes (Biography classed with subject)	Lacking in arrangement of main heads Subheads logical	None	Modern	Each class indexed No general index

[5] Courtesy of Harlan C. Brown, Librarian, N. C. State College

In 1875 the first of the modern systems was outlined by W. T. Harris. Similar to it in many ways was the Dewey Decimal system, now more generally known, which appeared the following year while Dewey was an undergraduate at Amherst. Fundamentally, the Dewey system provides for ten general classes of books, one hundred divisions, and one thousand subdivisions. Thus, its arrangement in multiples of ten provides for an almost unlimited number of sub-subdivisions and other highly differentiated classes. The Dewey system is brief, simple, and clear, and could be used internationally, since it is based on arabic numerals, which are more widely used than any one alphabet. (See the diagram on page 12.) However, the system is now becoming obsolete, and many libraries are resorting to various improvisations to care for new accessions not fitting easily into the present classifications.

In 1879 appeared the Cutter Expansion system, which has been described by librarians as the most scholarly of cataloguing methods. This system used letters rather than numbers and was thus able to make twenty-six large classes, each divided into twenty-six parts, and so on. Thus, within easy range the Cutter plan provides for over 18,000 class numbers. The author made several revisions and expansions in the next fifteen years but died before the system was completely developed. Though the Cutter plan is basically a very sound and logical method of cataloguing, it is already becoming obsolete because it is incomplete.

The Library of Congress classification began in 1899, because of the inadequacy of existing methods for classifying so large a collection. It was not published, however, until 1910. Meanwhile, the James Duff Brown system appeared in 1906. Though it has many of the better features of both the Dewey and the Library of Congress classifications, it never has been very widely used.

The Library of Congress system was made to fit just the large collection of books in the Library of Congress. For that reason, some of its divisions may seem overexpanded and some underdeveloped for the general library. However, the very fact that it has the coverage and the authority of the Library of Congress makes it usable and desirable for many smaller collections. Another convenience is that the Library of Congress assigns new books to certain classifications, and the smaller libraries can use the same call numbers.

DEWEY DECIMAL SYSTEM[6]

0-099	General						
100-199	Philosophy						
200-299	Religion						
300-399	Sociology						
400-499	Philology						
500-599	Natural Science	500-509	General				
600-699	Useful Arts	510-519	Mathematics	510	Mathematics, General		
700-799	Fine Arts	520-529	Astronomy				
800-899	Literature	530-539	Physics	511	Arithmetic		
900-999	History	540-549	Chemistry	512	Algebra	512	Algebra
		550-559	Geology	513	Geometry	512.1	Systems of Algebra
		560-569	Paleontology	514	Trigonometry	512.2	Numeric Equations
		570-579	Biology	515	Descriptive Geometry	512.3	Algebraic Equations
		580-589	Botany			512.4	Series—Fractions
		590-599	Zoology	516	Analytical Geometry	512.5	Combinatory Analysis
						512.6	Proportion and Progression
				517	Calculus		
				518		512.7	Involution and Evolution
				519	Probabilities		
						512.8	Higher Algebra
						512.9	Problems and Tables

[6] For use of this diagram the writers are indebted to W. P. Kellam, Librarian, University of West Virginia. The original diagram of the Dewey system and that of the Library of Congress system (see p. 13) show further subdivisions.

Library of Congress System[7]

- A General Works—Polygraphy
- B Philosophy—Religion
- C History—Auxiliary Sciences
- D Universal and Old World History
- E American History—General
- F American History—Local
- G Geography—Anthropology
- H Social Sciences
- J Political Science
- K Law
- L Education
- M Music
- N Fine Arts
- P Language and Literature
- Q Science
- R Medicine
- S Agriculture
- T Technology
- U Military Science
- V Naval Science
- Z Bibliography and Library Science

Q (Science):

- Q Science, General
- QA Mathematics
- QB Astronomy
- QC Physics
- QD Chemistry
- QE Geology
- QH Natural History
- QK Botany
- QL Zoology
- QM Human Anatomy
- QP Physiology
- QR Bacteriology

QA (Mathematics):

- QA Mathematics
- QA1-27 Periodicals, Study, Teaching, etc.
- QA28-29 Biography
- QA31-35 Early Works, before 1800
- QA36-43 General Works since 1800
- QA47-59 Tables
- QA71-85 Instruments
- QA101-145 Arithmetic
- QA152-297 Algebra
- QA300-433 Analysis
- QA443-699 Geometry
- QA802-935 Analytical Mechanics
- QA—etc.

QA152-297 (Algebra):

- QA152-297 Algebra
- QA152-165 Textbooks
- QA190-201 Linear Substitutions
- QA211-218 Theory of Equations
- QA241-246 Theory of Numbers
- QA251-263 Universal Algebra
- QA273-275 Probabilities
- QA281 Calculus of Differences

[7] For use of this diagram the writers are indebted to W. P Kellam, Librarian, University of West Virginia.

Basically, the Library of Congress classification is like the Cutter Expansion system but makes use of many features of the Dewey Decimal and other systems. The general divisions are designated by letters, subdivisions by double letters, and subdivisions by double letters plus numbers.[8] (See the diagram on page 13.)

By far the most widely used systems of cataloguing libraries are the Dewey Decimal system and the Library of Congress system. All the systems are compared on page 10.

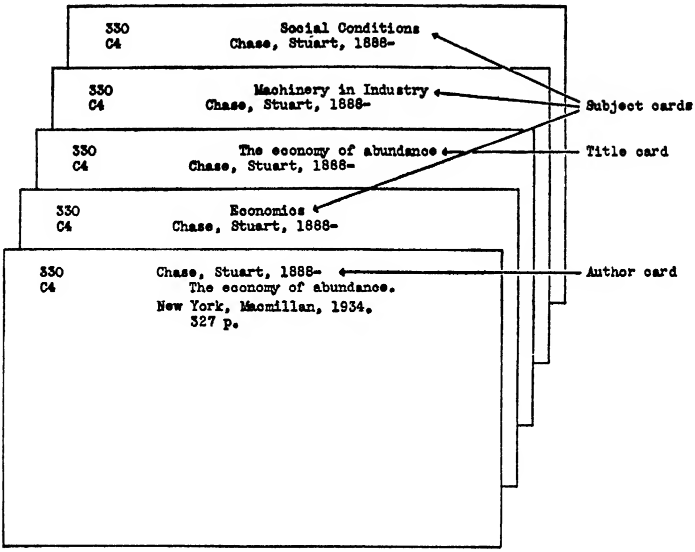
Library index cards are usually filed under three headings, author, subject, and title. That is, each book has at least three cards. Additional cards may be used to designate joint authors or subject matter properly falling under more than one head. In addition to these three types of information, the catalog card indicates the classification number of the book, along with an auxiliary, or *cutter* number for the author. By these numbers, the library attendant may quickly find the book on its shelf. The student himself uses the numbers if he wishes to find reference texts shelved in the general reading room, or if he is far enough advanced to have the privilege of studying in the library stack room. (See the diagram on page 15.)

The catalog card also indicates the publisher, publication date, edition, number of pages, height in centimeters, use of illustrations or diagrams, and any bibliography that may be included. Frequently, the card gives additional information about the contents of the book. Intelligent inspection of the card catalog records will save many hours of useless effort in any sizable piece of research. (Study the sample card on the opposite page.)

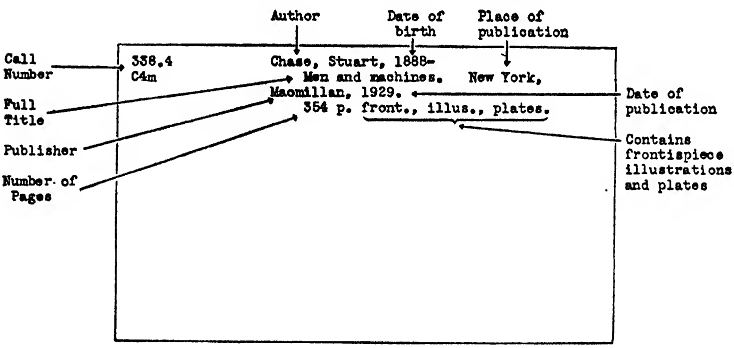
The technical student interested in the very latest developments in his profession, however, must do his major research in journals rather than in books. It takes months and even years for technical material to find its way into textbooks, even after it is accepted by the profession; but technical journals begin discussion within a few weeks and continue to record the progress made in later researches.

The difficulty in using journals for library research is that their contents are so multitudinous and varied that the card catalog could not begin to make record of them all. At best,

[8] This discussion of indexing systems is based on an unpublished manuscript by Harlan C. Brown, Librarian, North Carolina State College.



Five cards index this book in the Dewey Decimal system.[9]



Study the information on the card. Will the book be helpful? Note the date of publication. Note the number of pages to get an idea of the extent and complexity of the material.[9]

[9] The authors are indebted to the pamphlet "So This Is the Catalog," The H. W. Wilson Company, for this diagram. Reprinted with permission.

the card file can do no more than indicate which journals are received. The task of classifying and indexing the individual articles must be performed in some other way. Fortunately for students and librarians alike, several very complete indexes are now available and are common property in libraries throughout the country. These indexes are classified in such a way as to provide for a minimum of overlapping and duplication.

Of chief use to the professional engineer and worthy of much study by the technical student, is the *Engineering Index*, published for more than fifty years in close collaboration with the Engineering Societies Library in New York City. Through various changes of publisher and editorial policy, the index has now settled into a standard annual volume, containing a subject index under one alphabet. A supplementary listing of authors is given in the back of each volume. The index is outstanding in its coverage, listing annually the articles in about three thousand journals, bulletins, reports, and transactions not only in the English language but also in the language of every principal foreign country. The index is unique in that it gives a brief summary of every article listed.

In addition to the annual volume, the index is available in the form of cards, issued weekly and classified under the several divisions of engineering. One may thus subscribe to that portion in which he is interested, and pay according to the service he actually receives. He may also obtain at nominal cost translations of foreign articles or photostatic copies of articles not available in his local library.

Also of great use, especially to the student, is the *Industrial Arts Index*, a subject index published since 1913 by The H. W. Wilson Company. Listing articles from about three hundred technical and commercial journals, the *Industrial Arts Index* duplicates some of the material of the *Engineering Index*, but lays less emphasis upon foreign articles, and does not give summaries. However, the index is excellent as a source of contemporary material, as it is issued in monthly pamphlets before accumulation in the temporary three-month, six-month, and the annual permanent volumes. Thus, many of its listings are on the shelves of libraries a whole year before those of the *Engineering Index*. The student is likewise impressed by the familiar format of the index, as it is one of several produced by the same publisher.

Of the more specialized indexes, the electrical engineer and physicist should know about *Science Abstracts*, an international index issued monthly since 1898, and divided into sections A and B, listing articles on physics and electrical engineering respectively. Chemical engineers will use *Chemical Abstracts*, published since 1907 by the American Chemical Society.

Of the general indexes, the technical student should surely be familiar with the *Readers' Guide to Periodical Literature* and the *New York Times Index*, each of which within its own scope lists many articles of technical or semi-technical interest. In all of the indexes, as in the card catalog, the student will soon become accustomed to the system of abbreviations and numberings and should experience no difficulty in their use. The technique of using the indexes is almost world-wide and needs to be learned only once.[10]

Use of handbooks. Of less use in library research but of infinitely greater use in design of structures and solution of problems are the scores of excellent handbooks now available to the engineer. The student will have occasion to use some of them in his regular course work; it is his duty to become acquainted with others he will need to use in his professional endeavors. Likewise, he should know of the various biographical listings of outstanding men in the profession, and the sourcebooks for manufacturers and manufactured products related to his branch of engineering. Some technical libraries keep on file many catalogs of engineering equipment. These catalogs are the most comprehensive single sources of information about these supplies.

Handbooks of general interest come from several sources. Published by private corporations are such compilations as Esbach's *Handbook of Engineering Fundamentals* (Wiley) and O'Rourke's *General Engineering Handbook* (McGraw-Hill). Others come from societies, such as the yearbooks of the American Standards Association, or the American Society for Testing Materials. Still others are issued by governmental bureaus and departments, such as the *National Directory of Commodity Specifications* of the United States Bureau of Standards, or the publications of the Bureau of Foreign and Domestic Commerce, or those of the Census Bureau.

[10] For the discussion of indexes, the writers are indebted to *The Use of the Literature by Chemical Engineers*, by O'Farrell and Schmidt, College of the City of New York. Article in mimeographed form, 1940

Handbooks in specialized engineering are far too numerous to list here. They usually come from the same publishers as do the general handbooks already considered, although most of them are edited by the technical societies. Departmental heads in engineering schools will usually have the better known of the handbooks, or may have arranged for their acquisition by departmental libraries. At either place, the student will have access to them.

Use of journals. When the researcher uses technical periodicals as a source of information, it is important that he recognize the different kinds of journals, so that he can better evaluate their contents.

Technical periodicals fall into four general classes: society journals, trade journals, house organs, and institutional journals. Society journals are published and sponsored by technical societies and circulated principally within the membership of the respective organizations. Since the circulation and financing are thus assured, such journals do not have to meet open competition in subscription or in advertising. Though most of them do accept a limited amount of advertising from reputable firms, some society journals take none at all. These periodicals exist mainly as a medium of exchange and permanent repository for research carried on within the society; therefore their articles tend to be more theoretical than commercial. Many of the articles are papers presented at sessions of the society. Usually society journals have no editorials, as they have little interest in economic or political affairs.

Trade journals, on the other hand, are highly commercial and competitive. They are frankly business ventures, engaged in by corporations with the same kind of stockholders as those financing the manufacturers of toothpaste or steam shovels. In order to give those stockholders a maximum return on their investment, trade journals accept large amounts of advertising, sometimes as much as three fourths of their total space. Low subscription rates and practical articles encourage wide circulation, which in turn stimulates greater advertising at higher rates. Many trade journals have vigorous editorial policies and frequently enter into controversial discussions such as those on governmental affairs, labor relations, and international problems. The research student, however, should not allow any bias exhibited by trade journals to prevent his use of their material;

indeed, trade journal articles are frequently of more value than others, because their findings have been proved by practical experience. Even their advertisements have informative value.

House organs are of several different types, varying in degree of intimacy between themselves and their parent organization; but they are all published by corporations not in the publishing business. They are usually interested in publicizing the affairs and the products of the parent company. Many corporations have journals for circulation only among the employees, as a means of intra-company good will and morale; others have journals for free distribution among prospective purchasers of the companies' products. Some corporations maintain such highly specialized laboratories that their findings are considered worthy of publicity, and the house organs of such corporations actually charge for subscriptions and accept limited advertising from corporations other than the sponsor. Such journals, unlike other house organs, are kept on file in technical libraries and are indexed exactly as if they were society or trade journals.

Institutional journals are those published by colleges and universities. Students in engineering schools frequently issue their own technical journals, limited to four or six numbers a year, containing articles by students and faculty members. Other institutional journals serve as mouthpieces for local scientific organizations, composed mainly of faculty members. One or two combine the technical journal and the alumni publications.

The following journals may be considered as typical:

1 Society Journal—*Mechanical Engineering;* published by the American Society of Mechanical Engineers; monthly; advertising, approximately 40% (cf. *Electrical Engineering,* 30%); editorials, two pages, material of interest to society (cf. *Electrical Engineering,* no editorials); articles mainly society papers and comments, some articles of practical application; price, 75c a copy; circulation, mainly among society members.
2 Trade Journal—*Electrical World;* published by McGraw-Hill Publishing Company; weekly; advertising, approximately 60%; editorials, two pages, political and economic news of interest to operating engineers; articles mainly discussion of effective engineering practice applied to local situations; price 25c a copy; circulation in open competition, among members of profession.
3 College Journal—*Southern Engineer;* published by engineering students, North Carolina State College; six issues in college

year; advertising, approximately 50%; editorials, none; articles, mainly by students, based upon reading; price, 25c a copy; circulation, among students (an exception to the typical college journal is the *Illinois Tech Engineer and Alumnus*, which combines material by and of interest to students, faculty, and alumni).

4 House Organs
   a Published for employees of a corporation, usually free: *The Spotlight*, published by Carolina Power & Light Company.
   b Published to publicize products and also to circulate among employees: *The Water Tower*, published by Chicago Bridge & Iron Company.
   c Published entirely to publicize company's products: *Ethyl News*, published by Ethyl Corporation; *U. S. Steel News*, published by United States Steel Company; *Explosives Engineer*, published by Hercules Powder Company (this journal has some advertising of other corporations).
   d Scholarly journals, published for general circulation, accepting advertising, charging subscription fees, and allotted space in technical indexes: *General Electric Review; Bell Telephone Magazine;* and others.

Taking notes. Collecting information from printed sources requires careful notes. The student cannot hope to remember detailed discussions in the dozens of articles and books examined for one research paper. Besides, his courtesy and honesty demand that he give exact data about the titles, authors, and dates of all material he uses for his paper.

For many years the standard medium of notes has been a small card, usually three by five inches in size. Such a card is easy to arrange and to file, but is too small for extended notes, even if it is reversed for use on the back side. Many researchers prefer larger sheets, half-size, or even full-size typewriter paper. Full sheets or half sheets are almost as easy to file as are smaller cards, and do not accumulate so rapidly; moreover, they have room for more discussion than can be placed on cards, and thus often obviate the necessity of returning to the source. However, the notations on the card or slip should make it easy, if necessary, to turn again to the article or book cited.

The essentials of good library notes are: (1) a clear-cut indexing word or phrase by which the note may be filed, the indexing phrase serving as both file title and topic heading for related matter; (2) a summary of pertinent material gleaned

from the article read—although for these notes many short-cuts and abridged constructions may be used, the statements should be clear to the writer even after they have been dormant for some time; (3) an accurate and complete statement of the source.

In general, notes for informal talks or for short papers will be less carefully made than those for longer papers prepared for publication or for presentation to learned societies. In the shorter treatment, organization offers only secondary problems; in longer papers it becomes a major consideration. Consequently, notes for longer papers must be much fuller. Examples of notes for papers of varying degrees of formality are:

1

> Weighing Devices
>
> Use in counting articles
> Use in weighing articles on conveyor
> Use in weighing very large articles or vehicles
>
> *Sou. Power and Ind.* 60.6. 65. 1942[11]

2

> Scales, Weighing Devices
>
> ---
>
> Scales are important in problems of output, inventory, and distribution
>
> Scales may be used for counting multiple units of uniform size
>
> Scales may be inserted as part of conveyor systems, weighing products as they are completed, or materials as they enter
>
> Properly designed, scales may be used for tanks of liquids, thus measuring volume
>
> Large scales may be designed for use in railroads or highways for weighing cars or trucks with cargo
>
> Westbrook, F. A., "Scales for Industry," *Southern Power and Industry* 60. 6. 65. 1942

[11] Volume, number, page or pages, year

Selection of notes. The careful researcher usually takes more notes than he actually needs. His problem then becomes one of selection. His choice will always be governed by (1) whether the material is contributory to the general thesis and purpose of the paper; (2) whether it will be meaningful to the audience to whom the paper is directed; and (3) whether it is relatively important. Holding strictly to these limitations may cause the writer to eliminate good but irrelevant material or to neglect many of his personal hobbies; but it will prevent his wandering from the topic or in some other way spoiling the purpose and effect of the paper. Besides, the rigorous rule of excluding irrelevant material will soon become a habit.

Arrangement of notes. The order in which material is presented will observe the same basic rules as those indicated for selection. That is, the arrangement must contribute to the purpose of the paper and it must be intelligible with a minimum of effort to the reader. For papers discussing a process, the chronological order naturally recommends itself; for papers on intricate theories or mechanisms, the best approach is the old method of going from the known to the unknown.

Many writers consider the old designations of introduction, body, and conclusion as outmoded. They point out that a carefully organized paper is all body, that the functions of the introduction and conclusion are performed by the simple expedient of giving first that part of the "body" which most easily leads the reader into the thought of the paper, and of giving last that portion of the "body" which leaves the reader with a unified impression of the whole discussion.[12] Papers based on reading research will probably have basic notes classified into these three groups before the writing begins. If the filing-card system of note-taking has been followed, it is an easy matter to arrange the ideas in what the writer considers the best order. Such a system likewise facilitates the choice and insertion of frequent headings and subheadings which are of great help to the reader in gaining a mental grasp of the logical divisions and the relation of parts.

The order of arrangement in a technical discussion tends at first to be deductive, and at the end to be inductive. That is, the early parts of the paper will proceed from generalities

[12] For a fuller discussion of the problems of arrangement and outlining, the reader is referred to the material in Perrin, *Writer's Guide and Index to English*, pp. 631ff.

to specific applications, whereas the last paragraphs usually present specific generalizations which are an outgrowth of the details presented earlier.

For example, in a descriptive article the writer will first give a total impression of the thing described, then pass into details of parts, and finally summarize for a more accurate impression at the end. In an article explaining an operation or process, he will give first his basic principle, proceed next to details of method, and present at the close the diverse applications. In an argumentative paper, he will begin by stating the reasonableness of his basic contention, then show how the particular problem fits into the accepted principle, and finally demonstrate how the principle may be extended to similar situations.

Outlining the paper. Arrangement of material is indicated by outlines, which enumerate not only the main categories of thought and their preferred order in time, but also their subordinate elements, each element contributing to the development of the main category of which it is a part.

Distinction should be made between an outline and a table of contents. Basically, an outline is *for the guidance of the writer*, and usually does not appear in the finished paper at all. A table of contents, on the other hand, is for the reader, and is an important part of the final paper. It usually indicates principal divisions only, and the page numbers on which they begin.

Outlines are of two types, topic and sentence. Topic outlines are much more widely used, perhaps because of their simplicity and undirected attitude. Their headings indicate matter only, not the direction of thought taken in the discussion of that matter. Sentence outlines have main heads and subheads expressed in the form of *complete declarative* sentences. Thus, each head or subhead expresses the general thought to be developed in that part of the paper, and often constitutes a topic sentence for the paragraph of discussion. Sentence outlines are especially useful in argumentative material, where the direction of the thinking is as important as its substance.

In either kind of outline, especially if others are to see the work, four important rules should be observed: (1) all units parallel in significance must be parallel in grammatical form; (2) any subhead must always be accompanied by one or more parallel subheads; (3) each subhead must be a part of the main

head under which it comes, and not parallel, unrelated, or superior to it; (4) each heading or subheading must not include any of the material properly belonging to another heading, or, as it might be expressed by some writers, the headings must be mutually exclusive.

A violation of (1) occurs in the following outline of things to be observed in operating a steam engine:

1 Steam pressure
2 Needs lubrication
3 Condensation
4 Valves must be timed
5 Speed

WRONG

If here each item is deemed of equal importance and of parallel significance, all should be expressed in similar grammatical form, usually in nouns:

1 Steam pressure
2 Lubrication
3 Condensation
4 Timing of valves
5 Speed

RIGHT

The following outline will illustrate a violation of (2). It should be remembered that it is illogical to set off a part of any topic and make no indication of the part or parts remaining.

A Adjusting the motor
 1 Setting the spark
 2 Adjusting the distributor points
  a Maximum clearance
 3 Adjusting the carburetor
  a Air intake
  b Nozzle
 4 Timing the valves
 5 Setting plug points
B Operating the motor, etc.

WRONG

In this outline, the second subhead under A is "adjusting distributor points." A subhead *a*, "maximum clearance," is set off, but no indication is given of the other things to be done in adjusting the distributor. If the problem of adjusting the distributor is important or complicated enough to need subdivision, more than one item needs to be indicated:

1 ——————
2 Adjusting the distributor points
  a Limiting of maximum clearance
  b Smoothing of contact surface
  c Controlling of pressure on points
3 ——————

RIGHT

Rule (3) is violated in the following example:

A Adjusting the motor
  1 Timing the valves
    a Setting the spark
      (1) Cleaning the carburetor
  2 ——————
  3 ——————
B ——————

WRONG

This outline violates not only the rule against the use of single subheads, but, more seriously, puts as subordinate ideas material which is clearly parallel to the first main head. Errors of this kind creep in easily when the writer comes to feel that division into subheads has a significance chronological rather than merely logical. Such fuzzy thinking has allowed unrelated matter, "cleaning the carburetor," to be inserted, though it is not even a part of the process discussed. A better outline would be:

A Cleaning the motor
  1 Carburetor
  2 ——————
  3 ——————
B Adjusting the motor
  1 Timing the valves
  2 Setting the spark
  3 ——————
  4 ——————

RIGHT

Rule (4) is violated in the following example:

1 Fuel
2 Coal
3 Oil
4 Kerosene
  a Natural gas
  b Gasoline
5 Crude oil
6 Artificial gas

WRONG

In this outline, the general term *Fuel* is so broad that it covers all of the others. The term *Oil*, properly a subhead under *Fuel*, is still broad enough to cover *Kerosene*, *Gasoline*, and *Crude oil*. Besides, the outline has no general heading for the two kinds of gas. A better outline would be:

A Fuel
  1 Coal
  2 Oil
    a Crude oil
    b Kerosene
    c Gasoline
  3 Gas
    a Natural
    b Artificial
B ————

RIGHT

Sentence outlines will observe the same general rules for headings, numberings, and relationships as the topic outlines used in the foregoing illustrations. In addition, each head and subhead must be expressed in the form of a *complete declarative* sentence. This type of outline is especially adapted to material for oral presentation, where persuasion is necessary. Students often use it for longer papers, since it is of aid in preserving a centralized theme for the whole paper. Principal elements of sentence outlines are indicated in this example:

A Government bonds are good investments in time of depression
  1 They are safe
    a The credit of the nation is behind them
    b The economic soundness of the country is conceded
  2 They are tax-free
  3 Their proceeds are not decreased by poor economic conditions
  4 They enjoy a ready sale, usually at a premium
B Utility stocks are better in periods of prosperity
  1 Income from stocks reflect the improved conditions
    a New industries consume extra power
    b Domestic consumption increases with improved conditions
  2 Stocks are usually tax-free
  3 Stocks reach high premium value and are extremely liquid

From all the preceding examples, it will be noted that a uniform system of numbering has been employed. It should be

remembered, however, that neither this popular system nor any other has yet been officially declared a standard. In the making of outlines, as in the making of bibliographies, the greatest rule is consistency in the use of one style. However, the outline form preferred by most authorities is as follows:

I ________
A ________
1 ________
a ________
(1) ________
(a) ________
(b) ________
(2) ________
b ________
2 ________
B ________
II ________

Outlines, especially topic outlines, are not usually punctuated. As in titles or addresses, the spacing of the material in separate lines constitutes sufficient division.

The student should examine outlines of papers given as models in other portions of this text. Suggested examples occur on page 227 and pages 349-351.

Devices for Documentation

Writings based upon library research must indicate their sources. Clear-cut references are at once a testimony to the authenticity of the statements in the paper, and a courtesy to the reader, who may wish to do additional study about the topic.

The methods by which research is thus documented have become somewhat standardized; yet the devices by which the sources are indicated are so numerous and complicated that they are worthy of much more extended study than can be given here. Many of the larger libraries, in collaboration with the English departments of their institutions, have prepared comprehensive pamphlets of instructions for doing this work properly. Each student should have access to such a bulletin, either by purchase or by loan from the reserve desk of his library.

The indication of references falls into two general classes.

One is the bibliography, the total list of sources which contribute to the study. The other is the series of exact references, called footnotes, at the bottom of each manuscript page. These notes give the sources of significant statements or quotations on that page. Footnotes may also be used for other explanatory matter, as will appear in later portions of this discussion.

Making the bibliography. The list of works consulted should be complete, even though some books or articles have contributed only background material. For extensive research, the listing will be subdivided into several groups, according to the type of material each part contributes; for papers the length of an average term paper or seminar discussion, the list will need no division. The bibliography should begin a new page in the manuscript, and should be the last section in any study.

Items listed in a bibliography should be arranged in alphabetical order by surname of author. In order to simplify such listing, the surname is given before the initials. Articles or books whose author is not indicated may be listed as "anonymous" and alphabetized among the *A*'s; however, if more than one or two such items occur, they should be listed by title, the first letter being used as a key for alphabetizing the anonymous matter among the surnames of known authors.

For indicating titles, certain very definite rules must be observed. Book, magazine, or newspaper titles must always be indicated by italics in print, underlining in typed or hand-written manuscript. Such titles may be considered as indicating publications complete within themselves. Titles of articles in papers or journals, and chapters in books must be enclosed in quotation marks and followed immediately by the italicized title of the work in which they occur. For books, it is necessary to indicate the publisher, with place and date of publication; for journals, it is sufficient to indicate the volume and page, and, usually, the date.

Punctuation of bibliographic entries is more largely a problem of consistency than of the slavish following of any one form. The student should see that the form chosen for any one item is carried consistently through the entire list. If he is writing for publication, he should see that he observes the customs of the journal in which his manuscript will appear.

For general use, bibliographical punctuation has become somewhat standardized into a form that is acceptable wherever

no special usage is required or customary. The following examples are illustrative:

Bitzer, E. C. "Filtering Cyanide Slides." *Engineering and Mining Journal,* Vol. 143 (June, 1942). pp. 60-63

Greene, A. M., Jr. *Principles of Heating, Ventilating and Air Conditioning.* New York: John Wiley & Sons, Inc., 1936

"Special Shoring for Building Excavation." *Engineering News Record,* Vol. 129 (July 2, 1942). pp. 68-69

White, Alfred H. "Fuels and Combustion." Chapter XXI, *Engineering Materials.* New York: McGraw-Hill Book Company, 1939

These examples illustrate the rules commonly observed for alphabetizing, italicizing, quoting, and punctuation. It is especially important to distinguish between italics and quotes in their use to indicate different kinds of title. Attention should also be paid to the arrangement of the information about cities, publishers, and dates. As a minor point, yet one indicative of the observant researcher, it should be noticed that commas or periods at the end of a quoted title always go *inside* the quotation marks. The student should study the arrangement and punctuation of bibliographies at the end of this and other texts which he uses.

Handling the footnotes. Technical papers based upon reading are usually written to inform rather than to persuade, and their citations are presented as evidence rather than as illustrations. Footnotes are therefore necessary to indicate the authority for the writer's conclusions, or to amplify the statements made in the text proper.

The most common and exacting type of footnote is that which identifies a direct reference or quotation used by the researcher in his discussion. Such a footnote may take a form like one of these:

1 D. G. Fink, *Principles of Television Engineering,* pp. 326-327

2 G. F. Wolfe, "Production Line Welding Plant," *Marine Engineering,* June, 1942, pp. 106-114

3 *Chemical and Metallurgical Engineering,* Vol. 36, No. 6 (1929), p. 350

4 M. W. Seavey, "Manufacturing Rivets for Airplanes," *Machinery,* Vol. 48, No. 10 (June, 1942), pp. 135-139

It is to be observed that footnotes place the initials and last name of author in their usual order, since citations have no

occasion for alphabetic arrangement. Information about publishers, and place and date of publication for books, and volume numbers of journals is usually omitted, as these details are included in the general bibliography.

Another kind of footnote may refer to a given source as typical of several developing the same general idea but not furnishing any direct reference for statements made in the paper. Such a note is more explanatory than documentary and may appear in somewhat this form:

> This theory has been developed by several writers recently. A simplified form is given in H. G. Watts, *The Design of Screw Propellers for Aircraft*, pp. 167-169.

Other footnotes are purely explanatory, and make no citations. They are in the words of the author but are placed in notes rather than in the running discussion of the text, where they would disturb the development of ideas. Such footnotes take a multitude of forms and simply explain some significant aspect of the material. However, their position and spacing indicate that they are notes rather than a continuation of the text:

> It should be recalled that a labor dispute disrupted production in this plant three weeks during this period.

Some footnotes, naturally, will combine features of all these kinds. That is, they may contain citations, general citations, and explanations.

By this time, it should be clear that footnotes are not stiffly formal and unchangeable. They exist in dozens of forms, easily adaptable to the need at hand. They should be regarded as tools whose use and efficiency may be learned and applied; their content and form should be fitted to their duty.

Among researchers, various conventions are observed for shortening or simplifying the footnote materials. Long titles with several citations are oftentimes shortened into some combination of key words for all except the first reference. Announcement of such a policy may be made in the first reference to that particular book, as

> W. V. Lyon, *Applications of the Method of Symmetrical Components*, pp. 192-193; hereafter cited as Lyon, *Symmetrical Components*

Various other short-cuts are frequently employed. The most common of these is the abbreviation *ibid.* (L. *ibidem,* the same), which is a complete footnote within itself, and means that the reference indicated is in the same place as the reference *immediately preceding.* Other common abbreviations are *loc. cit.* (L. *loco citato,* in the place cited), and *op. cit.* (L. *opere citato,* in the work cited). The first of these is employed in much the same way as *ibid.*, except that it is less definite; the last is accompanied by the surname of the author, and can be used only when just one work of this author has been previously cited.

Less common forms employed for shortening footnotes are as follows: *supra* (L., above), used to refer to a previous discussion in the present paper; *infra* (L., below), used to refer to a later discussion; *passim* (L., here and there), used to indicate ideas gleaned from various parts of a source work, but, not definite enough to be indicated as coming from one place; *sic* (L., thus), used in brackets immediately after an expression to indicate the exact form in which the expression appears, often with misspelling or other error; *circa* or *ca.* or *c.* (L., about), used to indicate approximation, especially of dates, when the exact time cannot be ascertained; *et seq.* (L. *et sequens,* and the following), used to indicate that the discussion referred to extends into succeeding pages or sections; *q.v.* (L. *quod vide,* which see), used to indicate a cross-reference to related material presented under another heading; *viz.* (L. *videlicet,* namely), used to precede a list or examples; and *et al.* (L. *et alii,* and others), used to indicate that the listing has other items not specifically named. Other abbreviations based on Latin words are *i.e.* (L. *id est,* that is); *e.g.* (L. *exempli gratia,* for example); and *cf.* (L. *confer,* compare).

Footnotes extending more than one line are single-spaced within each item, and frequently between the separate notes. In typed or handwritten papers, footnote space at the bottom of the page is separated from the text by a horizontal line approximately 1½ inches in length.

In material prepared for ultimate appearance in print, footnotes may be inserted between two horizontal lines immediately following the point of reference. Such arrangement facilitates the work of the typesetter. After the galley type has been proofed and set up into separate pages, the compositor may

quickly remove the footnote lines and place them at the bottom of the page. Work in typed or handwritten final form always has footnotes at the bottom of the page.[13]

[13] Several pamphlet discussions of documentation are available. Material here used is based principally on *The Form for the Term or Research Paper* by Hinkle and Johnson, Stanford University Press. The student may profitably examine such other treatments as those in Perrin, *Writer's Guide and Index to English;* in the University of Chicago *Manual of Style;* and in Trelease and Yule, *Preparation of Scientific and Technical Papers.*

CHAPTER 2

The Elements of the Whole Composition

COMPOSITION is what its name indicates, a composite of many parts or elements. Good composition cannot be produced from poor elements, even though the final form of a piece of writing may not make those elements immediately obvious. Indeed, the smoothness of a composition is evidence of the care used in the wording and arrangement of the parts. As in a musical composition, the identity of the separate notes is lost in the total harmony.

But the musical composer's work rests, of course, on the choice and arrangement of those notes. In the same way, the technical writer must know and exploit the elements of the composition. He must be able to recognize not only the correct form but also the most desirable form for his paragraphs, sentences, and words. Such problems are treated in the usual first-year handbooks of English, but some further examination of these elements may prove helpful to the technical student.

Paragraphs

A paragraph is a mechanical division on the written or printed page which indicates that the material in such a division has independent or separate importance. In thought, a paragraph is that unit of writing which treats of a single topic or part of a topic; in amount, a paragraph is that quantity of writing which can be readily grasped by the reader without tiring his eyes or straining his attention. Usually both purposes may be served by paragraph divisions of five or six ordinary sentences, extending from about one fifth to one half of a typed page.

One of the purposes, however, sometimes outweighs the other. Paragraphs on large topic divisions may be split apart for convenience of reading, or a paragraph of concentrated thought may extend beyond the length of easy eye-grasp, to

avoid disturbing the logical development by a mechanical break.

Classification of paragraphs. Three broad kinds of paragraphs may be recognized in most technical writing: isolated statement, loosely related statements, and closely related statements.

Isolated statement. Paragraphs of isolated statement, having no problems of inter-relationship, are discussed and illustrated elsewhere in this chapter (section on Functions).

Loosely related statements. In a paragraph of loosely related statements, several facts which are generally related but do not develop a single idea are placed together to provide a summary or chronological presentation or compact handling. Directions or instructions often take this form; the sentences each present a separate idea, related to others only in that each instruction contributes to the general procedure.

> Before the motor is started, the fuel supply should be carefully checked. Oil of proper weight should be placed in the crankcase. The adjustments of the carburetor and ignition system should be checked. Cooling water must be in the radiator. Oil pump, fuel pump, and water pump must be in working condition. After the motor is running, it should be kept at low speed until all its parts are lubricated.

Closely related statements. In most technical writing, the paragraphs consist of closely related sentences, each growing out of the preceding and leading into the following. The various methods of paragraph development, the use of transitional or linking devices within the paragraph, and the use of topic sentences are discussed in another section of this chapter. (See pp. 42-50.)

Many authorities still divide all writing into the classical categories of narration, description, exposition, and argumentation. Experience and common sense, however, indicate that these forms seldom occur singly. The able writer frequently uses all these methods within a comparatively short space. The purpose of writing is to convey ideas, not to illustrate artificial division and classification; accordingly, the writer should not limit himself to any one method of writing, but should make his choices and combinations fit his needs.

The technical writer, especially, needs to remember that his discourse, like his profession, is functional in nature. He should

make his writings perform their assigned functions, regardless of any rhetorical vagaries he may seem to commit.[1]

However, it is well for technical writers and other writers to recognize the different kinds of development, the better to adapt the different methods to the purpose at hand. The following discussion should be interpreted from this point of view.

NARRATIVE PARAGRAPHS. A narrative paragraph reveals one incident or one unit of conversation. Thus, its length may vary through much wider limits than would the length of a paragraph of exposition. Especially is it likely to be short, in order to give the impression of rapid action, or to indicate abbreviated exchanges of conversation. It should be noted that each change of speaker is indicated by a new paragraph, with its complement of quotation marks, introduction or identification of speaker, and indentation. Narrative discourse, however, occurs but seldom in technical writing.

DESCRIPTIVE PARAGRAPHS. A descriptive paragraph is one which gives an impression of outward appearance in color, shape, or bulk. Although it is not a major form of writing for the technical man, it is useful in giving a total picture of an object or layout in one quick glance. It frequently makes some kind of comparison that is easily grasped, and then adds details which use the indicated general impression as a background for their own significance. This principle is frequently employed in the description of buildings or layouts.

> The dining hall and kitchen are built in the form of a large capital H. The cafeteria is on the main floor of the left-hand leg of the H, the kitchen is on the same level of the cross-member or link between the two legs, and the general dining room is in the right-hand leg. Incinerator and service entrance are close to the kitchen, in the inverted U-shaped alcove between the legs and the south side of the kitchen. In the opposite alcove is a ramp for easy entrance to the cafeteria, which is high above ground level.

This device is frequently used even in expository writing, where shape or fundamental impression is an essential detail for the understanding of a movement, structure, or mechanism.[2]

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[1] An excellent treatment of the functional approach to paragraph development occurs in Perrin, *Writer's Guide and Index to English*, Chaps. III and IV, Scott, Foresman, 1942.

[2] It should be remembered that descriptive writing seeks to portray *one* article, emphasizing the qualities which differentiate that article from others of its kind; expository writing seeks to portray the qualities which are common to all articles of a certain kind.

Elliptical gears have the appearance of lengthwise sections cut from a watermelon. Driving and driven gears are always of the same size, so that their frequency and relative positions are always the same. In operation, the gear teeth at the point of greatest radius of the driving gear engage the teeth of the driven gear at the point of smallest radius. Thus a small rotary movement of the driving gear produces a relatively large rotary movement of the driven gear; but as the gears revolve further, at the next quarter-revolution, the short-radius teeth of the driving gear are meshed with the long-radius teeth of the driven gear. At this point, a large movement of the driving gear produces but small movement in the driven gear. If the driving gear revolves at uniform speed, the driven gear operates at alternate high and low speed, with a complete cycle of high and low speed each half-revolution.

EXPOSITORY PARAGRAPHS. An expository paragraph is one which explains a structure, operation, or principle. It may begin with a definition and then add details and examples to assist the reader in obtaining a clear understanding.

Linoleum [is] a heavy floor covering made of jute or burlap surfaced with a composition of powdered cork, oxidized linseed oil, gums, or other ingredients, and coloring matter. The linseed oil is exposed to the air in a succession of thin films until it is of a rubber consistency, or it is thickened by heating until it becomes a spongy mass, after which it is ground, mixed with the pulverized cork and other ingredients, and then applied to the foundation and rolled smooth. In *inlaid* linoleum, the pattern is built up from the base in the colors of the design and is therefore permanent. *Cork carpet* is a variation of linoleum. The final process is a thorough seasoning in drying rooms. . . .[3]

Expository paragraphs may take other forms or orders. (It should be noted that some of these overlap with the "narrative" and "descriptive" types—this whole classification, somewhat artificial, is for convenience in analysis and discussion.) The movement may be, especially in the explanation of a process, almost entirely *chronological.* It may be from *cause to effect* or from *effect to cause.* An expository paragraph may consist of the development of an *illustration, analogy, comparison,* or *contrast* for a given idea; it may be made up of simple *enumeration of details* about some main point. For further discussion and illustration of the kinds of paragraphs—from the standpoint of

[3] Reprinted from *The Columbia Encyclopedia,* by permission of Columbia University Press.

constructing them—see Development of Paragraphs, pp. 44-49.

ARGUMENTATIVE PARAGRAPHS. An argumentative paragraph, for the engineer at least, is essentially exposition so chosen and arranged as to induce belief or to influence action. The technical man seldom engages in debate for the sake of debate. His opinions are presumed to be those of an expert, disinterestedly advising on a proper course to be pursued.

> In this new era of air power, a fleet is no protection. If the RAF were suddenly put out of commission, hardly a ship could reach England, for all that the British Navy could do. Whether Britannia's fleet can remain in the Mediterranean depends not at all on the size or skill of that fleet; it depends on who controls the Mediterranean skies. The usefulness of all navies is being rapidly restricted. Tomorrow, with the advent of true air power, the whole epoch of modern history conditioned by sea power will be ended. Under such circumstances, rhetoric about "our impregnable ocean ramparts" becomes dangerous gibberish.[4]

Relationship of paragraphs. Paragraphs seldom stand alone. They are usually units in longer compositions, where they must stand in logical relationship to paragraphs preceding and following. The degree of this relationship varies widely. It may be only that separate paragraphs have to do with similar products, professions, or personalities, as in a feature column or editorial page of a technical magazine.

> A paste machine operator, while threading his machine for 3-ply paper, got too close to the nip where the sheets came together, and his right hand went into the nip. It resulted in a severe contusion of the workman's right hand. The cause was attributed to an unguarded squeeze roll, which hazard was eliminated after the injury occurred.
>
> An employee on a wood yard went onto a moving conveyor to dislodge jammed wood. His foot became caught in the conveyor chain, and he was carried over the sprocket, which resulted in the amputation of two toes that were too badly crushed to be saved. The cause was the employee's disregard of safety instructions. . . .[5]

Normal relationship between adjacent paragraphs means simply that the latter paragraph discusses a different aspect of

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[4] *Reader's Digest*, July, 1942, pp. 120-121. Adapted from Alexander De Seversky, *Victory Through Air Power*, Simon & Schuster, 1942

[5] "Safety and Welfare," *Pulp and Paper Magazine of Canada*, June, 1942, p 550

the same material (Example 1), or advances the thought beyond the stage it reaches in the preceding, amplifying or illustrating it (Example 2).

1

Heating may be detected by [smelling] the odor given off from the pile or by thrusting iron rods into the pile and feeling them with the hand, or by [using] a thermometer. Steam should not be confused with smoke, for water vapor coming out of the pile in winter time may produce visible steam when there is no appreciable heating within the pile.

Heating of stored coal seems to be due to the action of the oxygen of the air on the coal surface, especially if it is a freshly exposed one. This action generates heat. If the heat is not dissipated, the temperature will continue to rise. The oxidation is more rapid at increased temperatures and a temperature may finally be reached where the coal is afire.[6]

2

Various methods are employed to supply salt to workers. Some plants add the proper percentage of salt to drinking water systems. This method, while entirely satisfactory, involves the installation of machinery and some attention to insure that the proper amount of salt is present in the water.

The use of salt tablets and tablet dispensing machines, placed near drinking fountains or on portable water coolers, has become increasingly popular. The tablets contain regular table salt, compressed under pressure to a uniform 10-grain size, which is approximately the size of an aspirin tablet.

Educational posters, placed on bulletin boards and near drinking fountains, are used to point out. . . .[7]

In the first example, taken from an article on spontaneous heat generation in stored coal, one paragraph discusses the methods of detection, through the senses of smell, touch, and sight, and the other discusses the causes of the phenomenon of self-heating of coal. The relationship between these paragraphs is that of mere addition. They could be reversed in order without any loss of meaning or emphasis.

In the first paragraph of the second example, occurring in a discussion on heat sickness, is given a general statement about methods, with the elimination of one method as too expensive

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[6] *Power Plant Engineering*, July, 1942, p. 63

[7] *Southern Power and Industry*, July, 1942, p. 90

and troublesome. The following paragraphs give details of two methods which have proved satisfactory. The ideas in the second and third paragraphs are subheads under the general thought in the first. The order of these paragraphs could not be changed without destroying part of the meaning.

Occasionally, paragraphs are even more closely related. Such nearness of relation may arise when one topic is so complicated that its discussion extends beyond the length of an ordinary paragraph; accordingly, the writer may divide the material for convenience to the reader.

> Dryer shells, plain cylinders, with necks cast on top and bottom in the smaller sizes and open at both ends in the larger sizes, are poured through a ring of pop gates on top. Procedure is similar to the method developed many years ago in the cast-iron pipe shops and still practiced where the pipes are cast in pits in a vertical position. A flat ring core with the required number of small rectangular gate slots in the inner edge is set in a suitable seat on top of the mold. The ring core also holds the main core accurately in the center of the mold circle. A circular dry sand basin is placed on top of the ring core.
>
> It is filled rapidly with metal and then kept full until the mold is filled. The individual small streams flow down alongside the main upright core and therefore do not strike the bottom with any force. A slightly different technique is employed where large dryer shells are made in loam molds. The top of the mold is left open. A circular cast-iron runner basin with suitable holes in the bottom for the gates is lined with loam and dried. This basin is propped up from 4 to 6 inches above the top of the mold. When the metal in the mold rises to within a few inches of the top, the man at the ladle stops pouring. The remainder of the metal in the basin flows through the gates to fill the mold. With a little repair the basin may be used to pour several molds.[8]

In these paragraphs, the division could have been placed at any of several points or omitted entirely; its chosen position occurs near the center of a discussion homogeneous enough for a single paragraph but long enough for two. Without the break, the material would have contained too much thought for easy grasp by the reader; with the break, it is retained easily by the eye and the mind.

All the foregoing paragraphs are but examples of divisions

[8] *Foundry*, August, 1942, p. 73

of discussional substance, each paragraph making for a general progression in the thought.

Occasionally, however, a paragraph is necessary for no purpose except that of transition from one element of discussion to another. Such paragraphs are always short; frequently they have but one sentence; usually they make some reference to the preceding discussion and set the foundation for the comments yet to come.

> . . . relative availability of material, men, and equipment, as contrasted with metals and plastics.
>
> However, a glimpse of present progress may be illuminating, examining the principal parts of aircraft in which plywood has demonstrated its suitability.
>
> Plywood fuselages of several types have been made. . . .[9]

Length of paragraphs. Aside from the discussion of mechanical convenience, little has been said about the actual length of paragraphs. Yet the amount of material included in one of these divisions, or, rather, the relative amount included in each of a series of such divisions, constitutes a principal means of indicating tempo, emphasis, and rhythm within the discussion.

In narrative writing, short paragraphs indicate hurried action or exciting incident; longer paragraphs are used for more leisurely movements or more involved detail. In descriptive writing, short paragraphs portray material of comparatively unrelated units; long paragraphs portray unified impressions.

In expository writing, paragraph length has much the same function as in descriptive writing, although the purpose is to convey information rather than impression. Short paragraphs indicate a relatively sharp division of material; long paragraphs are developed in a more detailed discussion of homogeneous matter.

The following examples illustrate the different effects produced by paragraphs of varied length. The short paragraphs could be combined to form one or two longer units, but the discussion would lose some of its emphasis and distinctness. The long paragraph could be split into two or three parts, but the divisions would do little except disturb the unity of thought in this description of the phenomena occurring in one cycle of the steam engine.

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[9] *Aero Digest*, July, 1942, p. 205

1

Anthracite coal must be fired evenly, in small quantities, and at frequent intervals. After it has been fired, it should be let alone, the best results being obtained where the fire tools are used as infrequently as possible.

With bituminous coal the difficulties in burning economically and without smoke are greater than with anthracite, and these difficulties increase as the percentage of fixed carbon decreases and that of volatile matter increases.

The various methods used in hand firing are the *spreading*, the *alternate*, and the *coking* methods. In the first, the coal is fired in small quantities at a time and spread evenly over the entire grate surface in a thin layer. This system is satisfactory for use with anthracite and some grades of bituminous coals.

The alternate method consists in throwing the coal first on one side of the grate and then on the other. In this way, but one half of the fire is covered with green coal at a time, and the volatile gases coming off from the fresh charge are burned as they pass over the incandescent bed of fuel on the other half of the grate.

In the coking method the fresh fuel is thrown on the front part of the grate. After the volatile matter has been driven off, the coked remainder is broken up and pushed back to the hotter part of the fire and another charge of fuel added at the front. This system is used for highly volatile and smoky coals.

Modern practice tends to working bituminous as well as anthracite coal as little as possible after it has once been fired.[10]

2

Early experimenters in steam-engine economy found that the surfaces of the cylinder wall and steam ports played a very important part in the economy of the steam engine. The inner surfaces exposed to the action of the steam in the engine naturally have a temperature very close to that of the steam itself. When the steam enters the cylinder, it comes in contact with the walls of the cylinder which have just been exposed to exhaust steam and are, necessarily, at a lower temperature than this entering steam. A part of this steam will, therefore, be condensed in warming the walls; as the piston moves out, more of the walls will be exposed, so that condensation increases to a point even beyond the point of cutoff. After the point of cutoff the steam expands, the pressure falls, and the temperature drops until a point is reached where the temperature of the cylinder walls is the same as the temperature of the steam in the cylinder. Condensation ceases at this point and the cylinder walls are by this time covered

[10] Allen and Bursley, *Heat Engines*, 5th ed., McGraw-Hill Book Company, p. 184

by a film of moisture. If the expansion of the steam is continued still further, the temperature in the cylinder corresponding to the steam pressure will be less than the temperature of the cylinder walls, and this film of moisture on the surface will begin to re-evaporate. Usually the amount of re-evaporation during expansion is very much smaller than the initial condensation and the cylinder walls are still wet when the exhaust valves open. This re-evaporation also continues during the exhaust stroke. It is very desirable that all the moisture on the surface of the cylinder be evaporated before the end of the exhaust. If it is not evaporated, the cylinder walls will be wet when steam is again admitted to the cylinder and the initial condensation will be greatly increased. The transfer of heat from the steam to the walls of the cylinder is always increased by the presence of moisture.[11]

Functions of paragraphs: a summary. Paragraphs thus perform many highly important functions for the technical writer. Besides providing mechanical division of material for easy reading and convenient grasp, they also may indicate closeness of relationship to other paragraphs, sharpness of division, advancement of central thought or addition of similar thought, transition, unity or lack of unity, total or partial impression, and many other things. A wise use of paragraphs to perform these functions is an essential to good technical writing.

Use of topic sentences. One test of a well-organized paragraph is that its general thought may be expressed in one sentence. Rhetoricians have long advocated the use of topic sentences, either at the beginning of a paragraph, where they provide the foundation on which to develop the thought of the paragraph; or at the end, where they provide a summarizing clincher for the ideas developed immediately before. Topic sentences, they say, are of special service in argumentation, where the logical unfolding of ideas is of paramount importance. For the same reason, topic sentences may be of good service to the writer of exposition, the kind of writing with which the engineer has most to do.

Yet, even a casual examination of contemporary technical journals would indicate that topic sentences are a lost art. One may search in vain for them, though the paragraphs may achieve a measure of unity and logic without any sentence which could be designated as a topic sentence. Perhaps the writers feel that

[11] Allen and Bursley, *op. cit.*, pp. 295-296

their material and its arrangement constitute all necessary evidence of unity. More likely they have never realized the value of topic sentences, and, therefore, have never formed the habit of using them.

Of course, the use of a terse topic sentence at the beginning of every paragraph would become extremely monotonous; by such lack of variety, the paragraph would lose more in effectiveness than it would gain in clarity. Even rhetoricians scarcely advocate a short topic sentence for every paragraph. Yet some kind of summarizing sentence is of value in gaining paragraph unity. Occasionally, one paragraph may contain several generalizing sentences, any one of which partakes of the nature of a topic sentence. Two illustrative specimens follow:

1

> Engineering is a form of professional education. Its group is defined particularly by special knowledge common to all and the character of skill required. As in other professions, individual success depends upon ability to cope with a multitude of diversified problems which arise continually and require rapid and accurate solution. Thus its value is not to be measured alone by the quantity of information acquired but also by the flexibility and versatility with which it develops. The vital requisite is a disciplined mind, with the perspective, the judgment, and the ingenuity necessary to derive the greatest possible value from the information available. This is so generally characteristic that unconsciously the term "engineering" is popularly applied to many acts which require skillful planning and execution, even though they are unrelated to science and technology. In fact, the generic meaning of the word is derived from the Greek meaning *ingenious*. It is only by a trick of etymology that it has become associated with engines. . . .[12]

2

> There is one other use of technical writing which should be mentioned. That is the public interpretation of scientific achievements in the newspapers, popular magazines, and books written for public consumption. It is the engineer's duty to help the reporter obtain a true story of his accomplishment. Often, it is desirable for the engineer to write a short 200- to 400-word story of his paper to give to the reporters. Recently one of our men gave a paper on paint failurė in Florida before the American Chemical Society. Normally, the paper would not have been considered of

[12] *Journal of Engineering Education*, December, 1941, p. 325

great importance and would never have come to the attention of the public. The paper proved that automobile finishes did not fail because of sunlight alone, as was supposed, but because of dew. It was a typical technical paper which merely gave the facts and left the interpretation to others in the field. As an experiment, we prepared a short popular article on the subject and released it to the newspapers. At the same time another paper was presented on high octane fuels, a highly technical subject at best. A short, popular write-up was likewise released on this paper. Much to our surprise, both stories were picked up by all the large news services and appeared on the front page in hundreds of papers from coast to coast. One cartoonist even made a cartoon on the paint story. By thus creating interest in the work that had been done, we had more requests for reprints of what we thought were not very important papers than we ever had for what we considered an important one. Since they were accepted by the popular press, technical men also thought they must be important. Even the best of discoveries needs a little selling.[13]

Development of paragraphs. Once the writer has decided upon the central thought he proposes to develop in a paragraph, he then has the option of several methods of development. Texts and handbooks have sorted out and classified many of these techniques of paragraph structure, so that almost every sentence in a paragraph falls into some labeled pigeonhole. It is doubtful that such fine distinctions are necessary to the clear expression of the professional engineer. However, the student engineer should be able to recognize the several methods of paragraph building, in order that he may not only observe their effective use by others, but also attain facility in their use in his own writings. A few of the better known methods of paragraph formation are discussed here.

DETAILS METHOD. Most common of the methods is that of giving *details.* A paragraph so developed may proceed deductively, by giving the general statement in the first (or topic) sentence and then arranging after it the several facts supporting the general statement; inductively, by presenting the details first and arriving at the general truth (topic sentence) at the end; or progressively, by going from the known to the unknown, or from the simple to the complex, and so on.

[13] T. O. Richards and R. A. Richardson, *Technical Writing*, Research Laboratories Division, General Motors Corporation. Presented at University of Michigan Summer Session, July 11, 1941

Thyratron tubes use various gases and mixtures of gases. The earliest type used mercury vapor, but this type of tube is quite sensitive to temperature changes. The grid characteristics are shifted materially by changes in the room temperature in which it is operated, and in low temperatures it is almost a vacuum tube. Thyratron tubes using argon gas are not affected by temperature changes, but high-pressure argon tubes have a low inverse voltage, which limits their application to low-voltage rectifiers. Tubes using low-pressure argon have a higher inverse voltage but are accompanied by a high arc drop which makes their efficiency low. A mixture of mercury vapor and argon has been found which provides the temperature-stable grid characteristic of the argon tube and the low-arc drop of the mercury-vapor tube. This type of tube has been very successful with certain regulating circuits, particularly at voltages less than 60 volts.[14]

General result, specific causes method. Closely similar to the development of paragraphs by the giving of specific details is the development by the statement of a *general result* and a listing of *causes* tributary to that result. This kind of paragraph is also closely related to the method of giving examples.

Errors due to the personal equation of the observer are of many sorts and in a sense are not subject to correction. Some observers are noticeably quicker than others and will therefore yield more accurate results when dealing with quantities in a state of flux. Some observers consistently read a given instrument low and others consistently read it high. Some observers can estimate readings between scale divisions more accurately than others. Some observers have so persistent a memory for past observations that they unconsciously allow this memory to influence subsequent observations, while others seem to be absolutely unaffected in this respect. No method can be prescribed for guarding against errors arising from this source. The best that can be done is to distribute the available observers to the best advantage and to check the performance of each before the test or periodically during the test by having several observers make the same determinations independently.[15]

General cause, specific results method. Occasionally, the order of development is reversed; the *cause* is stated in the topic sentence and the *results* enumerated in the later statements. Such development is adapted to discussions of various

[14] *Electrical Engineering,* Transactions Section, August, 1942, p. 613
[15] J. A. Moyer, *Power Plant Testing,* McGraw-Hill Book Company, p. 295

kinds of installations, attachments, or adjustments necessitated by some basic condition in which a mechanism must operate.

> The primary circuit of the electrical ignition system functions as an oscillator, which produces very high-frequency radio waves. These waves are similar to those emitted by radio transmitters; therefore they interfere with the reception of radio by drowning out the weaker effects of energy received from a distant source. It is necessary to cover every part of the ignition system with a metal case that will absorb the radiated energy, confining it to the shielding system. Ordinarily, a close-fitting case surrounds the magneto, and metal tubing encloses the spark-plug leads, terminating in a tight-fitting metal cap on the spark-plugs. Special spark-plugs are available for shielded systems.[16]

EXAMPLE METHOD. Paragraph development may be very effectively performed by the use of specific *examples* to illustrate the principle under discussion. Classroom discussions and lectures use that method perhaps more often than any other; it is just as useful to the writer who wishes to instruct his reader. Familiar examples are especially helpful in discussions of phenomena frequently observed but not yet understood by the reader.

> Microorganisms are particularly important in industry, where the food technologists use them in the preparation of such food materials as vinegar, pickles, sauerkraut, butter, cheese, acidophilus milk, and a large number of other fermented products. . . . bacteria, yeasts, or molds bring about changes in the food materials which may be highly desirable. For example, in the manufacture of Roquefort cheese, both bacteria and molds play an active part. This particular cheese is classified as a mold cheese, since its characteristics are due mainly to changes which have been brought about through the action of the mold.
>
> Although certain species of microorganisms produce desirable changes in foods, . . . others . . . bring about very undesirable changes. Oranges and apples in storage are destroyed primarily by molds. If a loaf of bread is permitted to stand in a warm, moist room, it soon becomes covered with a mold growth. Meat, unless preserved, is attacked by bacteria and decomposed, giving rise to a very offensive odor. Unpasteurized milk, when allowed to stand at room temperature or above, soon becomes sour.[17]

[16] H. F. Lusk, *General Aeronautics*, The Ronald Press, p. 231
[17] *Journal of Chemical Education*, August 1942, pp. 387-388

Analogy method. Wherever discussions involve unfamiliar materials, abstractions, or units not within the range of human vision, *analogies* are a ready substitute for *examples*. Electrical engineers find them especially helpful in explanations of current flow, induction, and the like; chemical engineers resort to them in explaining molecular structure or electronic movement.

> The patterns of crystals composing titanium oxide—the whitest white substance man has yet found for making and keeping white paints white—are physically at considerable variance. One of the three known types of titanium dioxide crystals is as compact as a clenched fist; the titanium and oxygen atoms in one of the other crystals are arranged in an open, loose fashion. Herein lies a minute difference of mighty significance.
>
> This pair of titanium dioxide crystals . . . are known as rutile and anatase. Rutile, the chunky fellow, is a newcomer. . . .[18]

Analogy is useful not only for explanation of static phenomena but for visualizing movements or displacements involved in transfer of energy.

> Self-inductance is sometimes referred to as electromagnetic inertia or electromagnetic mass. The magnetic flux linked with the moving electricity constituting an electric current endows that electricity with the property of mass. Hence, when an impressed voltage tends to set electricity in motion and thus form a magnetic flux producing current, a self-inductance reaction, commonly called the self-induced voltage, opposes the impressed voltage. That component of the impressed voltage which is balanced by the self-induced voltage is termed the e.m.f. of self-induction. After an electric current has produced magnetic flux, and the two are linked together, the electricity flows on its own "momentum" unless some countervoltage is established, as by the insertion in the electric circuit of electric resistance or capacitance. When any voltage reacts on the electricity to tend to stop its motion, the self-induced voltage acts in the direction in which the electricity is moving to tend to keep it moving in that direction. In this respect, electricity behaves very much like matter.[19]

Definition method. Discussions of unfamiliar materials make free use of paragraphs developed by *definition*. Frequently, one such basic paragraph contains several definitions

[18] *Scientific American*, August, 1942, p. 76
[19] C. R. Underhill, *Magnets*, McGraw-Hill Book Company, pp. 14-15

necessary to an understanding of explanations to come later. (For a discussion of Definitions, see Chapter 6.)

> A dielectric may be considered as an electrically elastic material. A "leaky" dielectric is a partial electric conductor. The equivalent is a perfect dielectric shunted by an electric conductor of exceedingly small cross-section, or of very great length, or both, in order that its resistance may be great. The dielectric strength of a dielectric is defined as the voltage per unit thickness required to puncture the dielectric. Units of voltage gradient are the volt per mil, volt per millimeter, and so forth.[20]

COMPARISON OR CONTRAST METHOD. Another type of development is especially useful in explaining unfamiliar material, or in laying emphasis on some particular point. This kind of development uses the pictorial method of *comparisons* (Example 1) or *contrasts* (Example 2).

1

> Emphasis should be made at this point that the Profitgraph is merely a chart—angles and lines and percentages and dollars—and in itself a static and useless thing, until someone takes it and uses it as he would an automobile route map. The preparatory work leading to the making of the Profitgraph is as important as that involved in preparing a road map. Even more important is the work of studying the Profitgraph and using it as a guide to a profit objective, in the same way the automobile driver who has a definite destination in mind but is lost on a detour uses his map.[21]

2

> It thus becomes apparent that the cooperative cannot serve its clients honestly and yet compete in this sense with private enterprise. If the consumers' interests were to be really served, most cooperatively sold products would bear little or no resemblance to their commercial counterparts. The consumer's tastes would have to be modified and his desires reformed. For his present choices involve products which are primarily profitable to produce and only secondarily, if at all, of worth to the buyer. It is therefore as impossible to compete with private enterprise and at the same time protect the consumers' interests as it is to seek simultaneously profit and the buyers' welfare. As often observed, production for profit has an antithetical relation to production for use.[22]

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[20] Underhill, *op. cit.*, p. 11
[21] C. D. Knoeppel, *Profit Engineering*, McGraw-Hill Book Company, pp. 94-95
[22] C. S. Wyand, *The Economics of Consumption*, The Macmillan Company, p. 421

ANALYSIS AND DIVISION METHOD. Technical writing may develop paragraphs by *analysis and division.* In such development, the discussional matter is broken down into successively smaller divisions, each of which is then seen in its proper relationship. This method has been aptly called microscopic outlining.

> Fundamentally there are only two requirements which a Diesel engine lubrication system must meet—that all the wearing parts be effectively lubricated under all operating conditions and that the oil consumption be not excessive. Lubrication troubles, however, are of several different kinds. There may be excessive carbon formation, which interferes with heat flow, chokes the parts, and generally impairs operating conditions; the pistons or piston rings may scuff or score, the rings may stick in their grooves [and not perform] their function of sealing the combustion chamber, and the pistons may seize in the cylinder. It is noteworthy that practically all of these ill effects occur in the cylinders. Bearing lubrication also has given rise to some difficulties in the past. . . .[23]

Naturally, in articles and reports all methods are employed, frequently many in a single paragraph. Observe the various methods and combinations of methods utilized in a single article. The better writers are those who have a command of several means of development and a keen eye for the distinctions in their use.

Transition devices. Evidence of relationship between sentences or paragraphs is given in several ways, but principally by the use of certain kinds of transitional or reference words which indicate a linkage of meaning from one part to another.

Demonstrative adjectives and pronouns, such as *this, that* (*these, those*), *some, others, such,* and the like, always depend for meaning upon a preceding substantive, usually in an earlier sentence, and frequently in an earlier paragraph. Linkage of meaning between such pronouns and their antecedents serves to connect the sentences or paragraphs in which they occur.

> Gasoline motors generate power from the rapid combustion of air and gasoline vapor. Some give one power impulse for two revolutions; others give a power impulse on each revolution.

Personal pronouns (*I, my, me; you, your; he, she, it; we, our; they, them*) or relative pronouns (*who, whose, whom; which; that; what*) are likewise capable of linking sentences or

[23] P. M. Heldt, in *Automotive and Aviation Industries,* August 1, 1942, p. 26

sentence parts by showing relationship between themselves and their antecedents. In order to show this connection, every pronoun must have an antecendent, clear in its expression and in its relationship. The use of *this* or *which* to refer to the thought of a whole sentence or clause is not only questionable grammar, but in technical writing at least is usually weak expression of transition (see the discussion of Vague Reference, p. 71).

Articulation of sentences and paragraphs is also accomplished by any of a multitude of connectives. In addition to the pure conjunctions, *and* and *but*, the English language has many words and phrases which serve no purpose except to show the direction taken by a thought as it springs from another thought already expressed. The following groupings indicate some of the many different kinds of these linkages. An intelligent (that is, not too frequent) use of them is a means for clarity and interest in expository writing.

RESULT: *consequently, as a consequence, so, then, wherefore, accordingly, as a result, therefore, hence* (it will be noticed that most of these terms are so-called conjunctive adverbs, requiring a semicolon when used to connect independent clauses).

OPPOSITION OR CONTRAST: *still, however, nevertheless, otherwise, yet, though, notwithstanding, in spite of, on the other hand, on the contrary.*

ADDITION OR FURTHERANCE: *indeed, moreover, likewise, similarly, furthermore, besides, again, next, finally, even, as well as, in fact, in addition to.*

Repeating of key words is another device for linking the parts of a paragraph or sentence, though it must be employed sparingly to avoid monotony.

Paragraph emphasis. Emphasis in paragraphs may be obtained by placing important ideas in emphatic positions—usually at the end of the paragraph, or at the beginning. The device of climactic arrangement is one method of obtaining emphasis by position, since it places the most important idea last.

Emphasis may be obtained by giving more space to important ideas; the device is usually called emphasis by proportion. Closely related to this method is that of repetition of important ideas. In both methods, the importance of the central thought is indicated by the sheer weight of the discussion.

In the same way, emphasis may be secured by placing ideas in separate paragraphs, even though they contain only one or

two sentences. A variation of this device is that of numbering, or otherwise indicating for distinctness, the separate paragraphs.

Less desirable, and indicative of the immature writer, are such methods as the overuse of *very* and other intensives, or of such purely mechanical devices as italics, capital letters, or underlining. The experienced writer is able to gain more emphasis by a careful use of definite concrete words; with them his writing suffers none of the monotony and inconsequence of artificial stressing of inherently weak or general words.

Exercises

A Develop, by appropriate methods, paragraphs on each of the following topic sentences. Indicate what method is used. Indicate what other methods could be used.

1 The Diesel engine operates on a principle different from that of the ordinary gasoline engine.
2 Proper use of the transit requires many adjustments.
3 Engineering curriculums should be extended to five years.
4 Quadratic equations are basic to engineering mathematics.
5 The town is arranged in an unusual manner.
6 The height of the dam is greater than that of a fifty-story building.
7 Aircraft construction is vastly different from automobile construction.
8 The telescope is an optical instrument which——.
9 Wood is better than steel for some structures.
10 The Copernican theory changed nothing except man's thinking.

B 1 Study a full-length paragraph in this or some other text. Make a list of transitional words and phrases, if any, linking the paragraph with other paragraphs, and a list of similar expressions linking the elements within the paragraph.

2 Put the thought of the paragraph into one sentence. Does the paragraph have such a sentence? Does it come at the beginning or end of the paragraph?

3 What method of development does the paragraph use? What other methods could it have used?

4 If the paragraph is long enough for two paragraphs, where could it be divided most effectively? What would be the effect of thus shortening the paragraphs? What would be the effect of combining this paragraph with the paragraph preceding or following, or with both?

5 If the paragraph is weak in arrangement or transition, explain how it could be improved.

C The following paragraphs are taken from student papers exactly as written. Criticize them for (a) unity, (b) use of transitions, (c) sentence order, (d) length, (e) method of development, (f) use of topic sentences. Rewrite each in what seems to be an improved form.

1

The key to the success of the proposed system is the large volume of sales at low unit cost. Consequently, the plant must be operated as close to capacity as possible. The total cost of the plant, land, and equipment will be approximately $200,000.00. Of this amount, $102,690.00 would be for building and equipping a car-washing rack with a capacity of six hundred cars for ten hours' operation. The size of the process and principles of specialization involved prevent a small beginning. Thus, the total $200,000.00 is an initial expenditure. The plant must be located so that the business will increase rapidly. For these reasons, an expensive site will be chosen.

2

The horizontally fired furnace has an advantage over the other two types in that it requires only one or two fuel jets where the other types require from four to eight fuel jets. The small number of jets simplifies considerably the fuel piping. The main disadvantages of horizontal firing are that the turbulence present causes impingement by and wear of the flame on the furnace walls, and that the horizontal firing necessitates bends in the fuel piping from an overhead storage bunker. The bends in the piping will cause some unevenness in the distribution of fuel in the furnace.

3

The relation between the electrical height and current distribution determines the intensity pattern of both the sky and the ground waves. Normally, and in the daytime, the antennas are adjusted so as to give a maximum radial distribution over the United States. After the California sunset, however, the distribution pattern is changed, making the sky wave along a great circle through San Francisco a minimum so that there will be no interference with KPO, which operates on the same frequency as WPTF. The change in the distribution pattern is brought about by shifting the phase relation between the two antennas. A receiving station established four miles west of the transmitter controls a recording voltmeter on the operator's desk, enabling him to keep a check on the directional state of the antenna radiation.

4

The gins are of two types, the loose-cut and the close-cut. The lint from the loose-cut gins is somewhat long and can be used to make mattresses, upholstery, etc. There are six loose-cut gins. The seeds pass through the loose-cut gins faster than they do through the close-cut gins. There are fifteen close-cut gins. These gins operate much slower than the loose-cut gins in removing the short lint from the seeds. This lint, being much shorter than the first, is employed in the manufacture of rayon, gun cotton, smokeless powder, plastics, moving picture films, and synthetic varnish. The lint must be removed because it will absorb some of the oil, and in this way a part will be lost. The gins employed here were manufactured by the Continental Gin Company.

5

The first work on the project consisted entirely of civil engineering. Three engineering crews were employed for this work. Their first assignment was to resurvey all of the original landowners' lines in order to see that the acreage corresponded to that given in the deeds. These plots were closed by the latitude and departure method to eliminate all possible errors. After these resurveys were checked and approved, work was begun on the project boundary lines. These lines were cut out six feet wide. All trees, regardless of size, were taken out. The lines were chained with 100-foot chains and stakes were put in every 100 feet. Where a boundary line cornered, the corner was marked with a concrete monument. These markers were four feet long and were buried so that approximately one foot was left above the surface of the ground. The boundary lines, as the original landowners' lines, were closed by the latitude and departure method.

D In the following selections, observe for the same qualities indicated in Exercise C. Where more than one paragraph occurs, analyze (a) the effect of length, (b) the use of transitional devices between paragraphs, and (c) the probable effect of combining the whole selection into one paragraph. If a selection of only one paragraph appears too long, suggest paragraph divisions and note their probable effect.

1

The pungent odor of Diesel exhaust gas has been traced to its aldehyde content in terms of formaldehyde. It was found that as the engine output (fuel rate) is decreased from high load, a point is reached where there is a substantial increase in exhaust

odor. Further decrease in the fuel rate results in increased odor, until a maximum is reached at the lean limit of combustion. Although the exhaust odors from different fuels differ at high loads, the quantities of aldehydes obtained and differences between fuels are of minor importance when compared with those at low load, as shown by odor ratings on exhaust-gas samples taken over the whole range from motoring to full load. Two distinct types of odor were distinguished, one from "rich" and one from "lean" operation. "Rich-mixture" odors were strong and heavy, but not particularly objectionable, while "lean" odors were very pungent, sharp, acrid, and objectionable. In most Diesel engines, the air charge per cylinder per cycle is substantially constant at constant speed; hence rich odors are encountered at and near full load, under conditions where an excess of fuel is injected, as evidenced by black smoke. "Lean" odors are encountered in the white smoke region at low loads, and grow increasingly intense as the load is decreased. At part load, combustion is substantially complete, as evidenced by an almost complete absence of smoke.[24]

2

The investment in a project has been defined as the sum of the first cost and working capital. This is the amount on which the investor wishes to make his expected return. The investor wishes to maintain this investment in the project throughout its life. This he does by making a so-called charge for depreciation which is really for the maintenance of capital. Thus, while the asset, such as a piece of equipment or building, actually depreciates in value for every year of service, the investor offsets this depreciation by either one of two processes.

In the first, he sets aside the charge for depreciation in a fund, which may or may not be placed at compound interest. In either case the sum of the depreciated value of the equipment, which is book value, plus the total in the depreciation fund plus working capital equals at all times during the life of the project the original net worth. The original investment has thus been maintained.

The second method does not set aside the charge for depreciation in a separate fund but keeps it within the business. As the asset depreciates in value, there is an equal offsetting value kept in the business which when added to the book value of the equipment and the original working capital equals at all times during the life of the project the original net worth. The original investment has thus been maintained.[25]

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[24] P. M. Heldt, in *Automotive and Aviation Industries*, September 1, 1942, p. 76

[25] C. E. Bullinger, *Engineering Economic Analyses*, McGraw-Hill Book Company, p. 130

3

Aerodynamics treats of air in motion; aerostatics deals with air at rest. In aviation, aerostatics deals with the problems of lighter-than-air craft.

All lighter-than-air craft are balloons, but present-day usage is to employ the term *balloon* only for craft which have no motive power and the term *dirigible balloon* or simply *dirigible* for a balloon supplied with motive power. The term *airship* is synonymous with *dirigible*; an airplane should not be called an airship.

Balloons are classified in two types, captive and free balloons. Captive balloons are moored to the ground and are used for observing artillery fire, etc. Captive balloons, if spherical in shape, have a strong tendency to rotate, so that they are usually elongated in shape with protuberances so designed that the balloon lies in the direction of the wind. This shape is called a kite-balloon. Free balloons are usually the so-called spherical shape. The upper part is a true hemisphere; the lower half is hemispherical except that at the extreme lower part the skin comes down to a long narrow tube called the appendix.[26]

4

An understanding of the ability of mercury vapor or of any gas or vapor to become "luminescent" or give off light under the influence of the flow of electrons is not a simple one. Technically, the interpretation involves a somewhat complicated treatise on the structure of atoms. Popular explanations of the theory of light production by an electric discharge usually resort to the idea of a "collision" between electrons (speeding from the cathode down the tube toward the anode at the other end) and atoms of mercury vapor with which the tube is filled. This bumping of electrons and atoms is as real in concept as two automobiles colliding on a highway, or as a bowling ball striking a setup of tenpins. The collision displaces electrons of the normal atomic mercury orbit, and radiations of a particular wavelength result as the displaced electrons return to their normal position in the atomic structure; this wavelength depends on the gas used and the degree of electron displacement. The production of light and other radiant energy from the low-pressure mercury arc comes about from the energy given up as the excited particles settle down to their stable or neutral state.[27]

5

Thermodynamics is a discipline which endeavors to describe the behavior of large scale bodies, particularly with reference to

[26] B. Jones, *Elements of Practical Aerodynamics*, J. Wiley and Sons, p. 384
[27] C. L. Amick, *Fluorescent Lighting Manual*, McGraw-Hill Book Company, p. 7

their thermal changes, by the use of dynamical concepts. As has already been emphasized, however, the method of attack is quite different from that of classical mechanics. Instead of visualizing a body as a system composed of a large number of material particles, whose motion is sufficient to account for its behavior, we consider the body as a whole, i.e., *macroscopically.* In particular its state is no longer defined in terms of component particles but rather in terms of large scale quantities, operationally defined. These are volume, pressure, and temperature, which are termed the fundamental state variables. Only two of these are independent, since for every body there exists a so-called "equation of state" connecting them. Thermodynamics does not pretend to relate pressure, volume, and temperature for all conditions of bodies, but only those in which the system if left to itself will remain unchanged, i.e., what we shall call *states of equilibrium.* Whenever the same state of equilibrium is reproduced, the state variables return to their previous values. In other words, they depend on the state alone and not on how the system got into the state.[28]

Sentences

A sentence is a single unit of composition which represents relative completeness of thought. Mechanically, it is indicated by a capital letter at the beginning and a mark of punctuation (usually a period) at the end.

Sentences of different relationships and arrangements present a wide variety of structure, expressive of many shades of meaning. From the shortest sentence, such as *Iron expands,* to the longest grouping of clauses coordinated and subordinated to express a single thought, sentences have in common the quality of containing a substantive[29] about which something is said. The variant forms and lengths of sentences are produced by the modifiers and adjuncts[29] attached to the subject or to the predication[29] about the subject.

Classification of sentences. According to grammatical construction, sentences are classified as simple, complex, compound, and compound-complex.

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[28] R. B. Lindsay, *Physical Statistics,* J. Wiley and Sons, pp. 41-42

[29] A *substantive* is a noun, a pronoun, or a phrase or clause used as a noun (subject, object, appositive) in a sentence.
An *adjunct* is an attached word or group of words; as used in rhetoric, *adjunct* usually refers to a modifier plus its own related words or phrases.
A *predication* is that which is said about a subject; it is thus the verb plus all its objects and modifiers.

SIMPLE SENTENCES. A *simple* sentence contains only one clause, that is, only one subject and one predicate. The subject and predicate may be only the bare words, as

> The bridge sagged.

Or, the subject or predicate or both may be expanded by any number of modifiers, so long as clauses (modifiers containing a subject and predicate) are not used, as

> The bridge recently constructed over the Crooked River near Folkstown sagged several inches in the center span because of inadequate support.

In the same way, the simple sentence may have a compound subject, a compound predicate, or both.

> The bridge and the approaches are of concrete. The bridge crosses the river and extends some distance over the flat lands.
>
> The bridge and its approaches are of concrete and have massive guard rails.

COMPLEX SENTENCES. A *complex* sentence contains one independent clause (subject and predicate capable of making sense while standing alone) and one or more dependent clauses (subject and predicate dependent upon other clauses for meaning). The subordinate clause may be any of several kinds, as

NOUN: *That the bridge must be built* is evident. The city will pay *whatever it costs.*

ADJECTIVE: The bridge, *which seems necessary,* will be built by the city. Plans are contained in an announcement *that came out yesterday.*

ADVERB: Materials will be sent *when they are needed. While one shipment is being used,* another will be in transit.

COMPOUND SENTENCES. A *compound* sentence contains two or more complete independent clauses, each capable of standing alone, but put within one sentence to signify a closeness of meaning not indicated by separate units. A compound sentence may take any of several forms, as

WITHOUT CONNECTIVE: Commas should not be used to separate clauses not joined by a conjunction; a semicolon is necessary.

WITH PURE CONJUNCTION: Clauses joined by a pure conjunction are closely related, *and* a comma before the conjunction is usually sufficient.

WITH CONJUNCTIVE ADVERB:[30] Clauses joined by a conjunctive adverb have a special kind of relationship; *however,* a semicolon is necessary between them.

COMPOUND-COMPLEX SENTENCES. A *compound-complex* sentence contains two or more independent clauses and one or more dependent clauses, as

The semicolon, which is discussed in another part of the book, is used between clauses not joined by any connective, and between clauses joined by a conjunctive adverb; and it has an important use between independent clauses which are long and internally punctuated, even though the clauses are joined by a pure conjunction.

Sentences in the foregoing discussion are classified on the basis of grammatical relationship. In rhetoric, sentences may further be classified as loose, periodic, and balanced.

LOOSE SENTENCES. A *loose* sentence places the main thought at the beginning, and puts subordinate material at the end. The thought is thus complete at one or more points before the end of the sentence.

The roof was inadequately supported, though the contractor argued that it would not be subjected to heavy loads in the mild climate of the South.

PERIODIC SENTENCES. A *periodic* sentence presents all its subordinate elements in the first part of the sentence and withholds its principal thought until the end. It is not grammatically complete at any previous point.

Unless the furnace has been properly banked with fuel and the draft adjusted for slow burning, the fire will soon burn out.

Considered as a separate entity, the periodic sentence is much the more emphatic, since its important thought is placed in the most emphatic position, the end. By comparison, the loose sentence appears wordy and anticlimactic. Yet it should be remembered that sentences do not occur as separate entities.

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[30] Conjunctive adverbs are difficult to define but easy to remember. The following words, when used to connect independent clauses, are usually called conjunctive adverbs, and are preceded by semicolons: *accordingly, besides, consequently, furthermore, hence, however, indeed, likewise, moreover, nevertheless, so, still, then, therefore.* The brief word *so* has many other uses, but should be classified and punctuated as a conjunctive adverb if it connects independent clauses. A good test is that as a conjunctive adverb its meaning is the same as *hence* or *therefore.*

Each sentence is effective or ineffective according to its placement and relationships among other sentences. A long succession of periodic sentences, each with its explosive terminus, would soon become unbearably monotonous. By the same token, a series of flat-ended loose sentences would be so boring that the peculiarities of their individual construction would be completely overlooked. The careful writer will choose his sentence-form in such a way as to gain a maximum of variety and interest; he will recognize the weaknesses and strengths of each kind of sentence; he will so intermix his sentences that each will add its contribution most effectively to the material in other parts of the discussion.

Within a short space, it is difficult to show the full effect of many kinds of sentences in a connected series; but the following example shows some of the many variations to be gained by mixing simple, complex, compound, and loose and periodic sentences. The tendency here is to use simple and loose sentences at first, to work through balanced and compound sentences in the center, and to place periodic sentences at the end.

> This speech level ["Vulgate English"] is a very real and very important part of the English language. It is not made up of lapses from any brand of reputable or standard English; it is the soil out of which reputable English has grown. It works very well in carrying on the private affairs of millions of people and is consequently worthy of study and of respect. That it is not used in carrying on public affairs—not used in business or in government or in literature—that it is not ordinarily printed, is due to social rather than to linguistic causes. For various historical and social reasons, the printable language is a selection of words, forms, and constructions now considered appropriate to public affairs.[31]

BALANCED SENTENCES. *Balanced* sentences may have the qualities of loose or periodic arrangement. In addition, they are formed through relatively striking parallelism of structure. Balanced sentences offer a particularly vivid means of expression, since both their form and language call insistent attention to the similarity of ideas. Their use is a method of gaining coherence, as the similarity of form causes the parallel parts to be more firmly interlinked with each other. Likewise, they make for emphasis by causing principal ideas to appear in pairs.

[31] Perrin, *An Index to English*, p. 630

A balanced sentence may have any of several forms; the parallelism may come between any of the major parts of the sentence.

MAIN CLAUSES: The four-cycle engine receives a power stroke once in two revolutions; the two-cycle engine receives a power stroke in every revolution.

SUBORDINATE CLAUSES: When the proper legal arrangements have been made, and when the town has actually sold the bonds, the streets may be paved.

PHRASES: The fire spread over the building and into the next block.

WORDS: Quietly and deliberately the plans were made for the launching of the new ship.

A particular kind of balanced sentence is one which contains a series construction, a grouping of three or more parallel elements. These elements may be clauses, phrases, or words, just as in other balanced sentences; but most series constructions are phrases or words.

PHRASES: Ships may be operated by private individuals, by corporations, or by naval units.

WORDS: The steel is tested, weighed, and shipped out as rapidly as possible. It is used for making nuts, bolts, and screws.

Parallel or balanced structure in series as elsewhere should be expressed in parallel language. Phrases should not be placed in parallel with words, nor should words be used in parallel with other words of different part of speech. The student is referred to the fuller treatment of this problem under "Parallel Structure," page 63.

Special problems. In this brief treatment of sentences, no attempt is made to discuss the basic grammar. It is presumed that the student is sufficiently grounded in fundamentals, by precept, observation, and practice. All that can be done here is to examine some of the constructions most troublesome to the technical writer, and to offer possible remedies for these difficulties. Anyone who studies technical journals or student papers in engineering schools soon realizes that most of the errors fall into a few categories. If the student will concentrate upon these errors, he will be able to make great improvement in his writing. A careful analysis usually reveals the cause of any vagueness of meaning, and it enables the writer to recast each sentence to make it say what it attempts to say.

A few of the most common problems are discussed here.

PERIOD FAULT. Though the period fault is sometimes discussed as an error of punctuation, it is essentially an error of grammar, brought on by the inability to distinguish quickly between a sentence and a fragment of a sentence. Most sentence-fragments punctuated like sentences are subordinate clauses or phrases, incapable of standing alone.

Technical writers are no more likely to commit period faults than are other writers; however, the engineer's tendency to use short sentences may tempt him to insert an occasional incomplete sentence. Moreover, the engineer's tendency to present material in tabular or semi-tabular form encourages the use of incomplete sentences. Besides, he often sees fragmentary sentences in the works of recognized writers who use such forms to secure some literary effect. The technical writer, however, is always on safer ground if he follows traditional rules of sentence completeness.

Period faults may easily be avoided if the writer forms a clear concept of the nature of the error. It should be remembered that *a period fault is the capitalizing and punctuating of a sentence fragment as though it were a complete sentence.*

The following examples may aid in clarifying difficulties.

The engine started. (Complete sentence; subject and finite verb, capable of standing alone.)

After the engine started. (Period fault; clause cannot stand alone; it is only the setting for an independent clause to be stated elsewhere.)

After the engine started, they climbed aboard. (Complete sentence, capable of standing alone.)

The concrete was prepared in the recommended proportions. The parts being mixed by weight. (First part is a complete sentence, but last part is a period fault; it has no finite verb, but only the infinite verb, *being mixed.*)

The concrete was prepared in the recommended proportions, the parts being mixed by weight. (Complete sentence.)

The concrete was prepared in the recommended proportions; the parts were mixed by weight. (Complete sentence, two independent clauses.)

The concrete was prepared in the recommended proportions. The parts were mixed by weight. (Two complete sentences.)

The concrete was prepared in the recommended proportions.

Which the foreman knew by memory. (Last part is a period fault; it is a subordinate relative clause.)

COMMA FAULT. Called variously the comma splice, the comma blunder, or sentence error, the comma fault is nevertheless a very definite kind of error. *A comma fault is the placing of a comma between two independent clauses not joined by a conjunction.*

With the definition clearly in mind, one should have no difficulty in recognizing the error or in correcting it. The following examples indicate some of the ways of correcting it.

COMMA FAULT: The stokers would not operate, the steam pressure was going down.
CORRECTION BY SEMICOLON: The stokers would not operate; the steam pressure was going down.
CORRECTION BY PERIOD FOR FIRST CLAUSE AND CAPITAL LETTER FOR SECOND CLAUSE: The stokers would not operate. The steam pressure was going down.
CORRECTION BY INSERTION OF CONJUNCTION: The stokers would not operate, and the steam pressure was going down.

Comma faults may be corrected by one change or another in wording or in sentence structure. The following are only a few of the many forms the sentence might use.

Because the stokers would not operate, the steam pressure was going down.

The steam pressure was going down because the stokers would not operate.

The stokers would not operate; therefore, the steam pressure was going down.

The stokers stopped and the steam pressure went down.

The steam pressure went down when the stokers ceased to operate.

Of lesser importance, yet serious, is the error of placing a comma before a conjunctive adverb joining two independent clauses. Some authorities classify it as a comma fault. It is corrected by the insertion of a semicolon in place of the comma.

COMMA FAULT: The water carried some mineral matter, however, no serious damage was done to the boiler.
CORRECTED: The water carried some mineral matter; however, no serious damage was done to the boiler.

One should remember that conjunctive adverbs are frequently the same words as plain parenthetic adverbs used *within* clauses, where they have no punctuation except commas before and after, just as would any other parenthetic expression. The semicolon is necessary only when the conjunctive adverb comes *between* clauses. The following examples illustrate the distinction.

CONJUNCTIVE ADVERB: The turbine is the proper size for this generator; however, it is too expensive for this plant.
PARENTHETIC ADVERB: The turbine is the proper size for this generator. It is too expensive, however, for this plant.
CONJUNCTIVE ADVERB: The company made money each year; moreover, it had a long record of good labor relations.
PARENTHETIC ADVERB: The company made money each year. It had, moreover, a long record of good labor relations.

FUSED SENTENCE. More serious than the comma fault is the "fused sentence," which *combines two or more independent clauses without any intervening punctuation.* It is worse than the comma fault, because it makes for great confusion and, incidentally, indicates that the writer's sentence-perception is too weak to recognize the need for a major break. Even a comma fault is an indication that the writer knows that some kind of break should be noted.

A fused sentence may be corrected by placing a semicolon, period, or conjunction where the punctuation has been omitted.

FUSED SENTENCE: The belt slipped off the machinery stopped.
CORRECTED: The belt slipped off; the machinery stopped.
CORRECTED: The belt slipped off. The machinery stopped.
CORRECTED: The belt slipped off, and the machinery stopped.

Fused sentences are likely to occur in technical writing because of the engineer's habit of taking rough notes in the field and putting them into form later. Punctuation omitted in the rough notes is sometimes omitted in the finished paper also.

PARALLEL STRUCTURE. The familiar rule of similar phrasing for similar ideas is frequently violated by the engineer in his writing and speaking. In his neglect of such a basic principle, he is at once robbing his writings of a chief source of clarity and coherence, and depriving them of the emphasis which grows out of the dual form.

Sentence elements joined by the pure conjunction *and* should be alike; this rule applies especially to connected phrases and words.

WRONG: The car runs smoothly and with considerable speed.
RIGHT: The car runs *smoothly* and *rapidly.*
WRONG: The factory is old and about to fall down.
RIGHT: The factory is *old* and *dilapidated.*
WRONG: Assembly lines poorly planned and which are not run at proper speed are not efficient.
RIGHT: Assembly lines *poorly planned* and *improperly scheduled* are inefficient.
WRONG: The turbines exhaust sometimes into the heating system and sometimes they exhaust into the atmosphere.
RIGHT: The turbines exhaust sometimes *into the heating system* and sometimes *into the atmosphere.*
WRONG: While the motor is idling and with its spark retarded, it operates quietly.
RIGHT: While *the motor is idling* and *its spark is retarded,* it operates quietly; or, With *slow speed* and *retarded spark,* the motor operates quietly.
WRONG: It is dangerous to have a leaky muffler and one should be careful to ventilate his car.
RIGHT: It is dangerous *to have* a leaky muffler and *to keep* the windows closed.

Sentence elements following the two parts of correlative conjunctions (*either-or; neither-nor; both-and; not only-but also*) should be parallel in structure.

WRONG: The transit was neither adjusted horizontally nor vertically.
RIGHT: The transit was adjusted neither *horizontally* nor *vertically.*
WRONG: Either somebody has tampered with the adjustment or the fuel supply.
RIGHT: Somebody has tampered with either *the adjustment* or *the fuel supply.*
WRONG: Before operating the boiler, the fireman should both check the water level and he should be sure about the draft.
RIGHT: Before operating the boiler, the fireman should check both *the water level* and *the draft.*
WRONG: The company not only loses money when the machines stand idle, but also because of inefficient operation.
RIGHT: The company loses money not only *when the machines stand idle* but also *when they are operated inefficiently.*

Sentence elements arranged in series should be parallel in structure.

WRONG: This lathe is strong, accurate, and has the latest equipment.

RIGHT: This lathe is *strong, accurate,* and well *equipped.*

WRONG: The railroad has a well-kept right-of-way, debt-free, and with powerful engines.

RIGHT: The railroad *has* a well kept right-of-way, *is* debt-free, and *operates* powerful engines.

WRONG: Highway Fifty extends from the coastal plain, runs across the Piedmont, and into the mountains.

RIGHT: Highway Fifty extends *from the coastal plain, across the Piedmont,* and *into the mountains;* or, Highway Fifty *starts* in the coastal plain, *runs* across the Piedmont, and *terminates* in the mountains.

WRONG: Whatever the attitudes of others may be; some of them may be politicians; even if temptation is strong and deceit easy, the engineer must be true to his profession.

RIGHT: Whatever the attitudes of others may be; whatever their narrow politics may suggest; whatever temptation he may have for deceit, the engineer must be true to his profession.

Sentence elements not parallel in thought should not be parallel in form. The difference in meaning should be suggested by a difference in phrasing. If the elements are in the form of a series, yet not parallel in thought, correction may be made by recasting the sentence to make both thought and form parallel, or by rewording the nonparallel ideas into nonparallel form.

WRONG: The employment of unskilled workers, aliens, and loafing is not tolerated in this work.

RIGHT: The employment of unskilled *workers, aliens,* and *loafers* is not tolerated in this work; or, Unskilled *workers, aliens,* and *loafers* are not employed here; or, *Unskilled* and *inefficient* labor cannot be used here. It is also against the rules to employ aliens.

WRONG: Geophysics provides a method of finding oil, several kinds of ore, and the probable means of exploiting them.

RIGHT: Geophysics provides a method of finding oil and some kinds of ore; it may also suggest means of exploiting these discoveries.

WRONG: The factory produces pre-fabricated houses, instructions for their erection, and skilled workmen to supervise.

RIGHT: The factory produces pre-fabricated houses; it will furnish skilled workmen to supervise the erecting of the buildings.

WRONG: Neatness and accuracy are necessary not only in the blueprints but also in using them.

RIGHT: Blueprints must be neat and accurate; they should be followed carefully.

WRONG: Both in figuring the rate of flow and in machining the orifice, Smith is quick with his hands.

RIGHT: Smith can quickly estimate the rate of flow and is adept at machining the orifice.

PASSIVE VOICE. In verbs, voice is that property which indicates whether the subject is acting or being acted upon. The active voice is inherently more forceful than the passive and is usually preferred. However, the giving of information in a report is frequently impossible in the active voice, unless the first person is used; and the engineer should not use the first person in a formal report. He should not say, *I started the motor*. He must say, *The motor was started*.

If used sparingly, the passive voice is not objectionable; indeed, it may even add a note of dignity and variety, and may be a welcome relief from a succession of active-voice sentences. But the passive voice has two grave dangers to the technical writer: first, it may be used so frequently that it becomes noticeable and tiresome; second, and much more serious, it breeds that most frequent of errors in technical writing, the dangling modifier. Students who learn to avoid danglers in general writing often seem totally unable to defend themselves against this construction in the cold-blooded, impersonal discourse of the engineer.

DANGLING MODIFIERS. The usual dangling modifier is a verbal at the beginning of a sentence. Because of its position, it seems to refer to the subject, but actually does not. It is said to dangle because it has no word to which it can logically be attached.

The most common type of dangler is the participial phrase.

Having adjusted the carburetor, the motor was started.
Calling frantically for help, the boat was dragging him under.
Urged on by his client, the blueprint was soon finished.

In the first and third of these sentences, the principal clause is in the passive voice. The active-voice main clause as used in the second sentence is much less common. In each of the sentences, the action expressed by the participle has no performing

agent. It may even seem to be performed by the subject. Since it actually does not relate to the subject, it is said to "dangle."

Danglers may be corrected in two principal ways. First, the dangling element may be reworded to form a complete clause.

> After the carburetor had been adjusted, the motor was started.
>
> While he called frantically for help, the boat was pulling him under.
>
> The architect was urged on by his client, and the blueprint was soon finished.

Second, the sentence may be corrected by rewording the main clause so that the subject is actually modified by the verbal previously dangling.

> Having adjusted the carburetor, the chauffeur started the motor.
>
> Calling frantically for help, the fisherman was going down with his boat.
>
> Urged on by his client, the architect soon finished the blueprint.

Dangling modifiers may be avoided in any of several other ways, some of them much better rhetorically than the sample corrections given here. For example, an absolute construction may occasionally be used.

> The carburetor having been adjusted, the chauffeur started the motor.

But, whatever the method, the solution is always the same: one must eliminate the verbal or so recast the sentence that the verbal may properly relate to the subject.

Other kinds of verbals left dangling may be corrected in the same way.

WRONG: *By closing the draft,* much fuel is saved.
RIGHT: By closing the draft, one can save much fuel. Closing the draft saves fuel.
WRONG: *To repair the motor,* it must be removed from the chassis.
RIGHT: To repair the motor, one must remove it from the chassis.

In all of the preceding examples, the danglers are verbals (participles, gerunds, infinitives) coming at the beginning of a sentence but not related to the subject of the sentence. Such danglers are by far the most common and account for perhaps

ninety per cent of the errors of dangling constructions; however, some other sentence-elements are classed as danglers and are discussed briefly here.

One of these is the elliptical clause, a subordinate clause from which the subject and part of the verb have been omitted. Since the subject is not expressed, it is understood to be the same as the subject of the main clause. If it is not the same, the relationship is not clear, and the clause is said to dangle.

> *When wiring houses,* the code must be followed.

Such sentences may be corrected by changing the main clause, to make its subject the same as that of the elliptical clause.

> *When wiring houses,* electricians must follow the code.

Or they may be corrected by expanding the elliptical clause into a complete clause.

> *When electricians are doing house-wiring,* they must follow the code.

Dangling constructions occasionally come at other parts of the sentence.

> WRONG: The engine developed much more power, *after adjusting the valves.*
>
> RIGHT: The engine developed much more power *after the valves were adjusted*; or, *After the valves were adjusted,* the engine developed much more power; or, *After adjusting the valves,* the operator obtained more power from the engine.

Here, as before, the difficulty is that no agent is clearly indicated for the action expressed in the verbal *adjusting.* When the agency is clear, or the phrase is changed to a clause, the verbal does not dangle.

Some authorities classify as danglers the adjective phrases *due to* and *owing to,* when they are used without definite nouns to modify. These expressions are wrong when used at the beginning of a sentence, since they refer to the action expressed by the verb, rather than to the subject, next to which they stand.

Causal relationships may be expressed adjectively or adverbially, according to whether the thing caused is the noun or the action of the verb. Therefore, one infallible rule for the use of the adjective phrases *due to* and *owing to* is this: if the

meaning is that of *caused by* (adjective), the expression is correct; if it means *because of* (adverb), it is wrong and should be replaced by *because of.*

WRONG: A large number of errors occur, *due to* careless writing.
RIGHT: Errors *due to* careless writing are numerous.

MISPLACED MODIFIERS. General rules of syntax require that modifiers shall be placed near the words they modify. Like most rules, this one is so simple that it is disarming; its violations are so subtle that the writer does not recognize them.

Two conditions foster this subtlety. First, the English word order usually places single-word adjectives before the modified nouns, and phrasal and clausal adjectives after the modified nouns. Second, one noun or verb frequently has several modifiers, not all of which can be placed next to the modified word.

Adverbs, except those of degree, usually come after the modified word. Obviously it takes thought to avoid confusion when more than one modifier is necessary, since all such modifiers attempt to come at the same place. To make scattered modifiers more confusing still, they often seem to modify an adjacent word rather than the word to which they are logically attached.

The usual word order for adjectives is indicated by the following examples.

SINGLE-WORD ADJECTIVE: It was a *new* building; it had *rambling* hallways.
PHRASAL ADJECTIVE: It was a structure *completed last year*; it had hallways *rambling from side to side.*
CLAUSAL ADJECTIVE: It was a building *which he had often visited*; it contained hallways *that rambled from side to side.*

The difficulties of the placing of adjectival modifiers may be observed in the following sentences.

The engine is for sale.
The *big Diesel* engine is for sale.
The *big Diesel* engine *which they looked at yesterday* is for sale.
The *big Diesel* engine *with the attached generator which they looked at yesterday* is for sale.

In the first three of these sentences, the modification is clear; no modifier is far from the modified word. But in the last sen-

tence, the clause *which they looked at yesterday* is far away from its modified word, *engine,* and is near to the word *generator,* which it therefore seems to modify. Moreover, the insertion of this clause has pushed the predicate, *is for sale,* entirely too far from the subject, *engine.* Several other arrangements are possible.

> The big Diesel engine with the attached generator is for sale *which they looked at yesterday.*
> The big Diesel engine is for sale *with the attached generator which they looked at yesterday.*
> The big Diesel engine *which they looked at yesterday with the attached generator* is for sale.

But the rearrangements are just as bad. In every one of the sentences, at least one modifier is obscure in its relationship. The sentence must have a complete recasting or must be split into two sentences.

> Yesterday they looked at a big Diesel engine and the attached generator which are for sale.
> The big Diesel engine with attached generator is for sale. They looked at it yesterday.

Adverbial modifiers give rise to the same difficulties, sometimes because they are separated from the verb by the object, which likewise needs a position near the verb. The following sentences are illustrative.

> The locomotive left *quickly.*
> The locomotive left the station *quickly.*
> The locomotive left the station where it had been standing *quickly.*
> The locomotive that had been standing *quietly* left the station *quickly under full steam.*

In these sentences, it will be observed that misplaced adverbs are more likely to occur as sentences become more complicated and more modifiers seek places near a single modified word. In the third sentence, the adverb *quickly* has been pushed so far from its modified word *left,* that it seems to modify the nearer word *standing.* In the fourth sentence, the adverb *quietly* is caught between two verbs, *standing* and *left,* and may modify either one; it thus becomes a so-called "squinting modifier."

The adverb *quickly* is still far from its verb, *left*, and seems more closely attached to the phrase *under full steam.* The remedy for misplaced adverbs, as for misplaced adjectives, is to recast the sentence or to put the thought into two separate sentences.

After standing quietly in the station the locomotive quickly left under full steam.

The locomotive had been standing quietly in the station. It left quickly, under full steam.

A special, but frequent, kind of misplaced adverb is the common word *only.* It seems to have a way of slipping into a sentence too early for its proper relationship. One constantly hears or reads such sentences as

It *only* pumps ten gallons a minute.
He had *only* taken six readings.
They had *only* reached the top a few minutes before.
The engine *only* knocks when it is pulling hard.
They *only* consider bids from contractors of good reputation.

A quick glance at these sentences indicates that in none of them is *only* attached to the word or phrase with which it properly belongs. The constructions make not only for inaccuracy and obscurity but also for slovenliness and fuzzy thinking. Placing *only* near the related word, phrase, or clause makes the sentence sharp and clear.

It pumps *only* ten gallons a minute.
He had taken *only* six readings.
They had reached the top *only* a few minutes before.
The engine knocks *only* when it is pulling hard.
They consider bids *only* from contractors of good reputation.

VAGUE REFERENCE. Pronouns are not properly used unless their antecedents are definitely expressed or clearly understood. In technical writing it is advisable to make these antecedents single words—nouns, or other pronouns. In each of the following sentences the italicized pronouns refer to general thoughts, not expressed in single words, but vaguely indicated by whole clauses.

The carburetor was badly adjusted, *which* caused the engine to lose power.

The furnace should be protected against overheating; ***this*** will prevent costly repairs.
The chain had lost one of its links, and *that* caused all measurements to be wrong.

Such sentences may be reworded so that each pronoun will have a definite antecedent or will be eliminated altogether.

The engine had a badly adjusted carburetor, which caused a loss of power; or, A badly adjusted carburetor caused the engine to lose power.
Protecting the furnace against overheating will prevent costly repairs.
All measurements were wrong, because the chain had lost a link.

The technical writer is likewise often guilty of other kinds of beclouded reference. The following examples illustrate a few of them.

ANTECEDENT IMPLIED BUT NOT EXPRESSED: He will not work as a lineman, as he is afraid to go up *one* that high.
RIGHT: He will not work as a lineman, as he is afraid to climb high poles.
ANTECEDENT IMPLIED BUT NOT EXPRESSED: The gas line was broken, and *it* was escaping rapidly.
RIGHT: The line was broken, and the gas was escaping rapidly.
ANTECEDENT IMPLIED BUT NOT EXPRESSED: The generator was overloaded and could not carry *it.*
RIGHT: The generator could not carry the overload; or, The overload was so large that the generator could not carry it.
VAGUE THIRD-PERSON REFERENCE: The town of Blanksville has discarded its streetcars; *they* now use busses.
RIGHT: The citizens of Blanksville have discarded their streetcars; they now use busses; or, Blanksville has discarded its streetcars and now uses busses.
VAGUE SECOND-PERSON REFERENCE: The generator is not satisfactory when shunt-excited. *You* must have separate excitation.
RIGHT: The generator is not satisfactory when shunt-excited. It must have separate excitation.
VAGUE SECOND-PERSON REFERENCE: *You* can't see steam until it condenses in the air.
RIGHT: Steam is invisible until it condenses in the air.
VAGUE FIRST-PERSON REFERENCE: We find little evidence of iron in this ore.
RIGHT: This ore seems to contain no iron; or, Indications are that this ore contains no iron.

The technical writer should remember also that appositives should have definite antecedents, exactly as should pronouns.

VAGUE APPOSITIONAL REFERENCE: He filled the tank while the engine was running, *a procedure* which is extremely dangerous.
RIGHT: He filled the tank while the engine was running, though such refueling is extremely dangerous; or, In spite of the danger, he filled the tank while the engine was running.

EXPLETIVES. The English language has long used the idiomatic *there is* and *it is* as openings for sentences. Though, like other idioms, they may be difficult of translation or explanation to foreigners, they are usually quite clear and understandable to Americans and Englishmen. Ordinarily, no objections are made to their use; they are simply listed and discussed among other constructions treated in the common handbooks.

However, to the general writer and especially to the concise technical writer, these expletives have three distinct dangers.

First, they seem to be habit-forming. They have a way of appearing several times within one paragraph or on one page, where they destroy variety and produce monotony. Exhibits like the following are not unusual.

> When working a problem in multiplication, *there are* two methods of obtaining the answer. By either straight multiplication, or by the addition of logarithms, *it is* possible to arrive at the answer. *It is* on the principle of logarithms that the slide rule is based. *There is* no instrument more useful to the engineer, and *it is* to his interest to learn to use it.

Second, sentences opened by expletives encourage the use of danglers, because of the obscure subject-verb relationship. In addition to the stilted monotony of successive phrases, the above paragraph contains a dangling construction, brought on by the awkward word order necessarily following *there is*. The sentence *When working a problem in multiplication, there are two methods,* etc., begins with an elliptical clause not at all related to the subject, which is buried behind the *there are*; besides, the subject is so unemphatic that the reader does not relate it to the introductory clause. Therefore, the clause dangles.

Third, sentences opened by expletives are usually wordy. Most of them make preliminary statements so large that the meaning must be restricted in some way, usually by a relative

clause or other construction requiring several words. Contrasts in the following sentences are indicative.

WORDY: There are sixteen bolts which must be removed.
BETTER: Sixteen bolts must be removed.
WORDY: It is difficult to determine what the result will be.
BETTER: The result is difficult to determine; or, Finding the result is difficult.
WORDY: If it is not possible to start quick fires, there will be a delay of several hours.
BETTER: Inability to start quick fires will cause a delay of several hours; or, Slow initial fires will cause a delay of several hours; or, Slow initial fires will delay operations several hours.

In addition to their three major weaknesses, these expletives have one minor additional fault. Both of them use words (*there* and *it*) which have definite meanings in other usage. Frequently, *there* or *it* may be used in both senses in one sentence. Confusion arises from such duality of language.

They decided to camp there but found that there was no wood. They had an ax to cut it, but it was impossible to find it. There was nothing there for them to do. It was necessary to change the picnic, although there had been much planning for it there.

Exercises

A 1 Find in this or another text examples of loose, periodic, and balanced sentences. Break each sentence apart in such a way as to indicate the nature and arrangement of sentence elements which cause it to fall into one of these classes. Be prepared to criticize the coherence, emphasis, or variety of each sentence as it appears in its own context.

2 Compose or find examples of simple, complex, compound, and compound-complex sentences. Break each sentence apart and name its elements.

3 Compose or find examples of sentences illustrating the difference between a compound sentence and a simple sentence with compound subject and predicate.

4 Compose sentences containing a series construction made up of (a) relative clauses, (b) prepositional phrases used as adjectives, (c) prepositional phrases used as adverbs, (d) nouns, (e) adjectives, (f) adverbs.

5 Classify the following sentences grammatically (simple, complex, compound, compound-complex) and rhetorically (loose, periodic, balanced). Explain the classification.

(a) The engineer must know what he is doing.
(b) He must learn that mathematics is a study of quantities, not matter, that it involves thinking, not manipulation.
(c) Whatever may be his fortune, he will continue to struggle.
(d) The house and garage were cleaned and painted.
(e) Motorcycles have a way of popping loudly when they are first started.
(f) He believes that one must live up to the ethics of his profession and that it pays to be honest, but he realizes that the engineer has many opportunities to be dishonest.
(g) While he was getting his lunch, the train moved off.
(h) The engine began bouncing; steam filled the room; the governor belt had broken.
(i) The book begins with a chapter on fundamentals and ends with a group of exercises.
(j) When the adjustments have all been made, when the fuel and lubrication have been supplied, the engine is ready to start.
(k) The town clerk, with all his duties and responsibilities and long hours, still found time to study by correspondence the subjects omitted from his course.
(l) The steam shovel roared into action, biting huge mouthfuls of earth from the hillside which had not been disturbed in a thousand years.

B The following sentences are taken from student papers and from the writings of professional engineers. Most of the sentences are poorly expressed; many of them have more than one error each; several have elementary grammatical or punctuational errors not within the scope of the present text yet in need of correction.

Examine each exercise closely to determine what it is attempting to say; then determine whether its meaning is obscure. Rewrite the exercise if revision is necessary.

1 The measured horsepower is checked with the ammeter and volt-meter installed in the dynamometer. Power in watts being the product of the voltage and the current.

2 The aero department is by no means an up-to-date affair; for many essential pieces of equipment are entirely lacking, that which is available is, in most cases, obsolescent.
3 There is total boiler horsepower of 1012 available.
4 Five runs were made in the extraction column using 10.5 in. of packing.
5 I have learned to think clearly while I am speaking which is a great asset because the greatest fault of many speakers is that of having to stop and think what they are going to say.
6 The paint has been removed from the starboard side of the hull from the gunwales to the water line and is ready for repainting.
7 The purpose of these tests were to determine the most economical coal to burn in the plant.
8 A time during which we shall be constantly under a personal tension.
9 His early schooling was very irregular, due to the movements of his family to different parts of the city.
10 What branch of engineering, was a difficult question.
11 Since State College was the nearest school to Goldsboro that offered ceramic engineering, it was only natural that that was the pick of Jack Brown, Jr.
12 After the pipe is laid the ditch must be filled in with shovels.
13 The earth for the fills should be obtained as far as possible from the cuts through the hills.
14 After two years of college work he could not see why an engineer should know so much about mathematics and sciences and quit school.
15 In this field, he could use his broad training, received from the preparation for several professions, to the best advantage.
16 The machine also separates the prints from the original tracings which cuts down the production time.
17 The latter proved to be a difficult problem due to the pile drivers, bulldozers and the like knocking the instrument out of level.
18 I wish to discuss some of the journals in this letter briefly.
19 His reason for doing so was because he wanted to work for the Seaboard in later life.
20 His "pet" interest in college are the band and anything mechanical.
21 Due to his father's profession, young Edwin was moved about from one state to another, this made schooling difficult.
22 The water flooded the whole street, caused by the broken hydrant.

23 Judging from the instruments he has in his room, he must be studying engineering.
24 Being a college student, the late hours were nothing unusual.
25 Close work with delicate readings, together with poor lighting, are bad on the eyes.
26 Due to various reasons he was unable to do so. The main one of these reasons being Dean Jones, of the basic division.
27 Thus the relationship of temperature and resistance does not hold for carbon, and it is one of the very few conductors whose resistance decreases as its temperature is increased.
28 When he graduated in 1940, he went to work as a laborer, this proved much more boring than school life.
29 Although this work was not along his line it did show him that work was work, and that you couldn't play while you worked.
30 There was no work done on this project.
31 The poor lighting causes eyestrain, fatigue, and distracts the student during classes.
32 A list of assumptions, sample calculations, and additional recommendations were included along with the above items.
33 What I would like to have in the report is the kind and size of work done by each machine. Also what is done along the line of furniture production.
34 If there is any other special thing you would like to know about the shop I would be glad to report on it.
35 Dick's father only saw his son for a week at a time every two or three months..
36 There are quite a few large boulders lying on and protruding from the ground.
37 The smoke stacks would be made with separate connections so they could easily be removed.
38 These screws seem to be slightly rusted which is the main cause of this error. I suggest that you oil these screws to see if this will cause them to turn easier. If this is not successful, I recommend that the instrument be returned to the maker for adjustments.
39 The motor was flooded owing to the primer getting caught.
40 Every employee must be considered capable to perform his work by the foreman.
41 This machine has done this work over a long period of years very effectively.
42 It is difficult to arrange the payroll, it has so many different kinds of workers.
43 The English courses were probably the toughest for him because there was a theme due every week.

44 *Owing to the careful guidance of his parents, his early child*hood habits and thoughts were of high moral standards.
45 He would like to write a paper on photography, and the library has several magazines on photography.
46 After attending graded, junior high, and high school, it was decided by this son and his parents that he should attend college.
47 Of course there has been exceptions to the rule, but this son has learned that the study of men is really much more useful than books.
48 The material became more viscous, causing the resisting torque on the motor to increase.
49 After allowing the steam chest to warm up the main nozzle was opened, this was done with the two secondary nozzle valves open.
50 In running this test there must be three things, (a) apparatus will be connected (b) have connections improved (c) start machine slowly.
51 I would advise building the aniline plant at this location after carefully considering the information at my disposal.
52 The class was divided, there were four men who worked in each group.
53 The discussion and plans will last for three days, so it will be necessary for you to hear all of it.
54 In reply to your letter of March 8, I have made a personal inspection.
55 The most important of these advantages are:
  a Stepless control
  b Wide range of control
  c Makes possible the use of simpler driving motors
  d Simple adaptation of automatic control
  e Reduces shocks from starting and changes in load
56 Since the circumference of the thin beveled edge of the sleeve is marked off into 25 equal divisions, by turning the sleeve one inch on its edge scale the spindle *D* will be moved 0.001 inch.
57 There were several questions to be answered which were designed to illustrate various points in the discussion.
58 The velocity of the air is considerably decreased. This allows the coarser material to drop back again.
59 Gasoline motors are lighter in weight, easier to start, and they are more variable in speed.
60 A railroad siding passes through the property, which makes the import and export of raw materials and products convenient.

61 To ascertain the efficiency of a gas producer the following data must be obtained: the quantity of fuel used, how much gas is generated, the heat of combustion of the fuel, and is the heat of combustion of the gas up to standard.
62 Instead of measuring the fuel by weighing, measurements by volume are sometimes used.
63 Due to the fact that the windings are revolving, there is a generative as well as an inductive effect.
64 The motor must either be fastened firmly to the floor or it will vibrate.
65 When testing again the joints were found to have no leaks.
66 The large gymnasium floor could have a stage at each end so that it could be used as an auditorium.
67 It is also recommended that an electric light be installed in the small alcohol-storage shed. Thus doing away with the need for the flash lamp.
68 There are courses included in this list which would be of interest to all students.
69 Due to the recent rubber situation and also since his father's business is connected with the rubber industry, he is very interested in the development of synthetic rubber here.
70 Although he liked math he knew that you could not make a good living teaching, so he began to look for a career which employed math.
71 The material in this field seems to be limited and he may not be able to make a report on this subject.
72 When the mention of ceramic engineering was presented to him, he immediately awoke from his vast search for a profession.
73 In the way of a final report, a survey of a clay property for use as a ceramic plant seems to be the most beneficial.
74 He is planning to write a paper on some phase of aircraft for his technical writing course soon.
75 If all these exhibits were under one roof and in one room, there would be a museum.
76 Whenever a person walks on the stairs, it sounds like thunder in every classroom. There is only one remedy for this.
77 The English department has had their classrooms in Pullen Hall for years, and now with the building in the condition it is it was thought best to transfer the English department to Peele Hall.
78 The inside structure is of wood which makes it dangerous in case of fire.
79 In Page Hall there are several rooms on the main floor which are used very sparingly.

80 No smoking should be allowed. Desks will be marred by cigarette burns. Also it is dangerous because of fire.

81 In preparing the land for building it will only be necessary to remove two pine trees.

82 There will be two external stairways of concrete and one internal steel stairway.

83 Probably the best arrangements that can be made are to make arrangements to move all engineering material from the college library to the reading room. But not only should there be books in the reading room. The most important reading matter is the engineering periodicals.

84 If a separate room, for each major branch of technical work, which included separate indexes for both periodicals and reference books, could be had, a saving of time and trouble for the library researchers would be the result.

85 Here is the report on an engineering reading room which you asked me for in your letter of August 31.

86 A very interesting item appeared in the October issue of the magazine and had to do with the use of oil-fired furnaces.

87 The vibrations are exceptionally high while bringing the turbine through the resonant speed.

88 The bridge consisted of three long truss spans, two were over the river and the other was across the shifting yards of the New York Central Railroad.

89 Corrections have to be applied to the observed weights due to the differences in buoyancy of the different objects.

90 If hatchway is too small, bucket can be closed before lowering if closing line is kept tighter than holding line.

91 Compound-wound three-wire generators were discussed, and in connection with this we reviewed the parallel operation theory concerning this type of machine.

92 The school of engineering should have a place to file their literature which is apart from the rest of the school.

93 Last year we received a donation of $2500.00 from one of our former students to be used by the engineering students.

94 The test was not completed, due to insufficient time, carelessness, and the men didn't know how to set it up.

95 It would give the engineering school something it has long needed. That is, a satisfactory place for the engineering societies to hold their meetings.

96 Before writing this report, the condition of the building, personnel, and equipment were taken into consideration.

97 If physically fit the course in flight training should be required, but if not physically fit a supervised course in flying should be given.

98 Using this plan, it seems necessary to build the most modern and complete building that can be built.

99 This dormitory is very important since the work required by the ceramic engineering department is difficult, long, and can best be done in the department itself.

100 This addition of a year's time would enable the students to thoroughly cover material that they previously only became acquainted with.

Words

The engineer should be just as earnest in seeking for accurate and effective use of English as he is in trying to make the best use of his calculus, his transit, or his drafting board. He should test the forces and variables of words as diligently as those of any materials that come to his laboratory, or of any new application of his knowledge. He should be no more ashamed of utilizing the grace and proportion of his language than he would be of the beauty of the long span of his bridges; he should strive for its accuracy as he would for the accuracy of his highway spirals or his factor of safety.

The engineer's effectiveness in his language depends upon many things. He must be genuinely interested in learning its matter. He must be diligent in mastering its fine distinctions. He must acquire skill in its manipulation. He must train his eye and his ear to appreciate its trim accuracy and vigor.

Vocabulary study. Possibly the greatest single means of accomplishing these aims is that of extended study of the formation of his language. Concomitant to that study are an ever increasing vocabulary and an appreciation of the contribution of the classical languages to modern English, especially technical English. Furthermore, such study enables the student to acquire additional words in family groups, just as he learns his mathematics by grouping similar operations, or his chemistry by grouping similar compounds. By such grouping, he can learn quickly units of knowledge which, if studied singly, would require years.

In studying the language, the student soon realizes that many technical words come from comparatively few sources. Many of these sources are Greek and Latin roots. Of course, not all engineering students may be expected to know Greek and Latin. But even a brief study of the chief roots, prefixes, and suffixes of both languages as they have contributed to engineering vocabulary will be of inestimable profit.

The following lists are merely suggestions. They should be supplemented by similar words from texts, papers, and discussions of engineering problems.

GREEK SOURCES

aer, the air (aeroplane, aerate, aerodynamic)
astron, star (astronomy, astrology)
autos, self (automobile, automatic, automaton, autonomous)
barys, weight (baritone, barometer)
chroma, color (chromatic, chrome, achromatic)
chronos, time (chronic, chronicle, synchronize)
dynamis, power (dynasty, dynamo, dynamic, thermodynamic)
elektron, amber, from the discovery of static electricity by rubbing amber with fur (electricity, electrolysis, electron, electrode)
ergon, work (erg, energy, metallurgy)
ge, *geos*, earth (geography, geometry, geology)
graphein, write, draw (graphic, autograph, telegraph, pantograph)
helios, sun (heliotrope, helium)
heteros, other, different (heterodyne, heterogeneous)
homos, like, same, common (homogeneous, homeopathy, homocentric)
hydor, water (hydraulic, hydrogen, hydrant, hydroplane, dehydration, hydrolysis)
idios, one's own, peculiar (idiosyncracy, idiom, idiot)
isos, equal (isometric, isothermic, isosceles, isochronous)
lithos, stone (lithography, monolith, lithia)
logos, word, science, discourse (logical, geology, physiology)
lysis, breaking (analysis, paralysis, hydrolysis)
mikros, small (microscope, micron)
orthos, good, right (orthographic, orthopedic, orthochromic)
petra, rock (petrology, petroleum, petrify, petrol, petrel)
phone, sound (phonetic, telephone, phonograph, orthophonic)
phos, *photo*, light (photoelectric, photograph)
pyros, fire (pyrometer, pyre, pyrene, pyromaniac)
teckton, craftsman, maker (technical, technique, architect, technology)
tele, distant (telephone, telescope, telegraph, television)
therme, heat (thermodynamics, thermal, thermometer, isothermic)

GREEK PREFIXES[32]

amphi-, dual, around (amphibian, amphitheater)
anti-, against (antipodes, antipathy, anticline)

[32] Usually attached to Greek roots only

cata-, down (catalog, catastrophe, cataract)
ek-, from, out from (eccentric, eclipse)
epi-, on, above, covering (epidermic, epicycloid, epitaph, epitome)
eu-, good, well (euphony, eugenics, euphemism, eulogy, evangelist)
hyper-, over, above (hyperbole, hypercritical, hyperacidity)
hypo-, beneath, less (hypocrisy, hyphen, hypodermic, hypochloride)
para-, beside, side (parallel, paralysis, paragraph, paradox, parable)
peri-, around (periphery, perimeter, period, periscope)
poly-, many (polygon, polyphase, polyhedron, polymeric, polytechnic)
syn-, with, the same (sympathy, syllable, synchronize, syntax, synthesis)

In addition to these and many other roots and prefixes, Greek has contributed numerous suffixes to English; but since the suffixes have only general interest and little specialized technical significance, they will not be considered here.

Latin contributions to general English vocabulary, direct and indirect, have been much larger than the Greek contributions; however, the proportion of technical words in Latin is much smaller than in Greek. Aside from medical terms, technical words of Latin origin are usually employed in a general popular sense also. The following list is a beginning.

LATIN SOURCES

aqua, water (aquatic, aquarium, aqueduct)
audio, hear (auditorium, auditor, audible, audience)
brevis, short (brevity, abridge, abbreviate, brief)
corpus, body (corporation, corps, corpse, incorporate)
duco, lead (conductor, induction, duct, aqueduct, ductile, conduit)
duo, two (duplex, duplicate, dual)
facio (*factum*), do, make (fact, factory, manufacture, effect, efficiency, factor, feat)
finis, end, conclusion (finish, finite, infinite, infinity, final)
flecto (*flexus*), bend (inflect, flexible, inflection, deflect)
fluo (*fluxus*), flow (fluid, flux, fluent, affluent, influence, confluence)
frango (*fractus*), break (fracture, fragile, fraction, fractional, infraction)
fundo (*fusum*), pour (fuse, fusible, foundry, funnel)
ignis, fire (ignite, ignition, igneous, pre-ignition)
insula, island (insulation, insular, peninsula, isolate)

jacio (*jactum*), throw (project, inject, eject, object, abject, projectile, projection)
jungo (*junctum*), join (conjunction, juncture, junction, adjunct, adjoin)
lumen, light (lumen, luminous, illuminate, luminary, luminescent)
lux (*lucis*), light (lucid, translucent, elucidate)
manus, hand (manage, manipulate, maneuver, manufacture, manual, manuscript)
mitto (*missus*), send (transmit, transmission, emit, remit, committee, missile)
pello (*pulsum*), drive, beat, strike (impel, repel, compel, pulse, impulse, repellent)
pendo (*pensum*), hang (pendulum, suspend, pendant, depend, compendium, impend)
porto, carry (portable, transport, import, export, deportment)
possum (*potens*), be able (potential, potent, omnipotent)
radix, root (radical, eradicate, radius, radiate, radiant)
rumpo (*ruptum*), break (rupture, corruption, interruption, disrupt, eruption)
scio, know (science, omniscience, conscience)
tango (*tactum*), touch (tangent, contact, intact, tangible)
torqueo (*tortus*), twist, turn (torque, tort, retort, distort, torture, torsion)
traho (*tractus*), draw, pull (traction, tractor, contract, distract, subtract, abstract)
urbs, city (urban, suburban, urbane, urbanity, interurban)
verto (*versum*), turn (convert, converter, versatile, divert, revert, verse, conversation)

LATIN PREFIXES[33]

a-, *ab-*, from, away from (avert, absorb, absorption, abjure, abnormal, abstain)
ad-, to, toward (attract, affect, annex, append, attend)
amb-, about, around (ambiguous, ambidextrous, amputate)
ante-, before (antedate, ante-bellum, antecedent)
circum-, around (circuit, circumference, circumscribe, circumspect, circumlocution)
com-, with, together (connect, corrode, correlate, collect, compound, collapse)
contra-, against (contradiction, controversy, contrary, counterelectromotive, countermand)
de-, down, decrease (de-air, decline, declivity, de-activate, descend, depression)

[33] Usually attached to Latin roots only

e-, *ex-*, from, out, out of (exhaust, exhibit, emit, evolve, eject, efface, extrude)
extra-, above, beyond (extracurricular, extravagant, extralegal, extraneous)
inter-, between (interurban, intercommunication, international, interest, intermediary, intermediate, interrogative)
omnis, all (omnipotent, omnibus, omnivorous)
post-, after (postdate, postscript, post-mortem, post-glacial)
prae-, before (preheat, precede, predetermine, prefix, prepare)
pro-, forward, for (produce, project, progress, procure)
retro-, backward (retrogress, retrograde, retroactive, retrospection)
sub-, under, less (subtract, suspect, subscribe, suburb, subordinate)
super-, over, above (superabundance, supervise, superheat, surmount)
trans-, across (transmission, transit, translate, transfix, transaction, transfer, transept)

It is noticeable that many of the prefixes, for example, *com-* and *ad-*, change their final letter into the same as the initial letter of the word to which they are attached. Thus arise such words as *corruption*, *collateral*, *acclaim*, *affiliate*, and others.

Suffixes from the Latin, like those from the Greek, are important contributions to the English, but they have no exclusive significance to the engineer. Therefore, they are not discussed here.

Though many technical words and word groups came into the language from the Latin and an even larger proportion from the Greek, it must always be remembered that individual words from almost every language have found their way into English, simply by contact of English-speaking peoples with speakers of other languages all over the world. Such words are usually nouns, the names of articles which are indigenous to the region. From later Continental languages come many words, some of them of technical significance, such as *cupola*, *cornice*, *volcano*, *gondola*, *stucco*, and *camera*, from the Italian; *armada*, *tornado*, *embargo*, and *ambuscade*, from the Spanish; *yacht*, *boom*, *truck*, *landscape*, and *reef*, from the Dutch; *stein*, *shale*, *nickel*, and *zinc*, from the German; *sabre*, *hussar*, *goulash*, from the Hungarian; and *lasso*, *cocoa*, *veranda*, from the Portuguese.

Asia has given such words as *bamboo*, *rattan*, *atoll*, *camphor*, from the Malayan; *bungalow*, *jute*, *calico*, *khaki*, *chintz*, *lacquer*,

toddy, teak, from the Indian; *rickshaw, kimona, soy,* from the Japanese; *typhoon, surge, tea, ginseng,* from the Chinese; *scimitar, caravan, awning, chess, pagoda, shawl, borax, check,* from the Persian. Australia and Africa contribute the characteristic words *boomerang, kangaroo,* and *oasis, zebra, gorilla,* respectively. Native to the Western Hemisphere are such words as *canoe, mahogany, guano, quinine, alpaca, totem, wampum, pemmican, chocolate, potato,* and *maize.*

Modern French is a source of many automobile and aircraft words, such as *chauffeur, garage, tonneau, chassis,* and *fuselage,* and many military words, as *camouflage, barrage, reconnoitre, reconnaissance, poilu,* as well as titles of officers, as *lieutenant, captain,* and the like. Names of scientists are often used to indicate names of units, especially in electricity, as *joule, watt, henry, ohm, ampere, volt,* and such other words as *fahrenheit* and *bakelite.*

A language from so many sources tends to have many synonyms or near-synonyms; however, words descriptive of technical concepts tend to assume one and only one meaning, narrowly limited. Thus, technical language has few synonyms. It needs few, as it has more occasion for accuracy than for variety or color. But the technical writer should avail himself of the multitude of slight variations of meaning in the English language, and should choose his words carefully for exactness.

The accumulation of a huge store of words is the surest method of gaining facility in expression. Only coarse distinctions can be made among words in a limited vocabulary; sharpness of choice comes to him who has many units from which to choose. The foregoing discussion indicates in a very elementary way the possibilities of accumulating a vocabulary through a study of word-sources. To this method the student should add constant dictionary study and a prolific interest in words. Students of vocabulary are made, not born.

Spelling difficulties. Accuracy of usage presupposes accuracy of spelling. In recognition of this principle, students are guided through the routine of spelling rules and exercises. They can probably spell any ordinary word if required to do so; yet many students and practicing engineers habitually misspell even familiar words. One may well ask why this discrepancy occurs between theory and practice. Surely the inconsistency does not occur because of lack of previous study. It is pointless here to

rehash the familiar rules; it is better to undertake a more mature study of reasons for continued misspelling, and to take from that analysis some indication of methods for improvement.

INADEQUATE RULES. In the complicated and variable English language, words take so many unpredictable forms that any number of spelling rules can barely make a beginning on the total problem of spelling. Vowels usually have at least three standard sounds each, with many additional sounds when used in combinations with other vowels or with consonants. The following words indicate some of the many sounds given by the letter *a* (alone or in diphthongs): *late, bat, bar, feat, feather, ask, law, draught, daughter, spare, rear, fair, waist, aisle, daub, moat, talk, aunt.* In unaccented syllables, *a* indicates several other sounds, barely distinguishable from one another in the unstressed pronunciation. Other vowels may have as many sounds. Consonants and consonantal combinations are almost as unobservant of rules. The sound of *th* in *this* and *think,* or of *ch* in *church, chagrin,* and *character,* is as uncertain as *oo* in *boot* and *look* and *soot,* or *ough* in *slough* (slou), *slough* (sloo), and *slough* (sluff).

One may excuse the English language for such uncertain spelling, on the grounds of the many sources of the language; but all the excuses cannot avoid the facts. The correct spelling of most English words must be learned by memory, observation, and hard study. Available rules rarely indicate the basic spelling for any word. They deal only with changes of spelling in the various forms of words. The more common ones are listed.

1 Doubling the final consonant. Rule: *Words accented on the final syllable, ending in a single consonant preceded by a single vowel, double the final consonant before a suffix beginning with a vowel.*

The rule is complicated in appearance but simple in practice. The following distinctions will aid the memory:

a "accented on the final syllable"
hop, hopping, repel, repelled (but *soften, softened, softening*)

b "ending in a single consonant"
get, getting, compel, compelled (but *lull, lulling, pull, pulled*)

c "preceded by a single vowel"
drop, dropping, confer, conferred (but *peal, pealing, repeat, repeated*)

d "suffix beginning with a vowel"
fitted, fitting, fittable (but *fitness, fitful*)

It should be noticed that the same root word may fall into or out of the rule if its accent shifts to or away from the final syllable of the stem. For example,

refer, referring, referred, but *reference*

The word *excellence* does not follow this rule, possibly because the *e* of the suffix appears to indicate the sound of long *e* for the vowel preceding the *l*. Some other words, not accented on the final syllable of the stem, have the final consonant optionally doubled or not doubled: *revel, reveling, revelling; level, leveled, levelled; tunnel, tunneling, tunnelling; marvel, marvelous, marvellous; travel, traveler, traveller.*

2 Dropping the final silent *e*. Rule: *Words ending in a silent* e *usually drop the* e *before a suffix beginning with a vowel.* The function of the silent *e* on the base word is to indicate that the preceding vowel is given the long sound; if the long sound is retained after the suffix is added, the silent *e* is usually dropped.

dine, dining (but *dinner*)
write, writing (but *written*)
ride, riding (but *ridden*)
grieve, grieving, grievance
plume, plumage, pluming
use, usage, usable

A few words, such as *love* (*loving, lovable*) and *move* (*moving, movable*), though their principal vowel is not given the long sound, still observe the rule when adding a suffix beginning with a vowel.

Words ending in *ce* or *ge* usually retain the final *e* to indicate that the *c* or *g* still has the soft sound.

notice, noticeable
advantage, advantageous
manage, manageable

Even in these words, the *e* is usually dropped before *-ing* (e.g., *managing, noticing, raging*) but is retained in such words as *singeing, tingeing,* and *dyeing,* in order to prevent confusion with similar words. A few words, such as *mileage,* are spelled

optionally with or without the *e*, but the preferred form retains the *e*.

According to the rule, the silent *e* is retained before suffixes beginning with a consonant.

move, movement
fate, fateful
wholesome, wholesomeness
pale, paleness

However, the silent *e* is dropped if it is preceded immediately by a vowel.

due, duly; true, truly; argue, argument

It is also dropped if the sound of the root vowel changes from long to short, e.g., *wise, wisdom*.

3 Dropping the final *y*. a Rule: *Words ending in* y *preceded by a consonant usually change the* y *to* i *before any suffix except one beginning with* i.

lady, ladies; tidy, tidiness; modify, modifies, modification; foggy, fogginess; icy, iciest (but *modifying*, etc)

Words of one syllable frequently do not change the *y* (*dry, dryly; shy, shyness*), though such forms as *drily* and *slily* are not uncommon. The *y* is usually retained before the suffixes *-like* and *-ship* (e.g., *ladyship, ponylike*); it is likewise retained in any compound based on the stems of *lady* and *baby* (e.g., *babyhood, ladylike, babydom*).

b Rule: *Words ending in* y *preceded by a vowel usually retain the* y *with all suffixes.*

volley, volleys; chimney, chimneys; whiskey, whiskeys (but *whisky, whiskies*); *sway, swaying; play, player; buy, buying; coy, coyness; joy, joyful*

Some single-syllable verbs change the *y* to *i* in the past or past participle, as *staid, laid, said, lain,* though some of them, as *stayed,* retain the *y* in the verb usage and drop the *y* for the past participle used as direct modifier, as "the staid old gentleman." *Daily* and *gaily* drop the *y*.

4 Miscellaneous. a Rule: *Words ending in* ie *usually change* ie *to* y *before adding* -ing.

die, dying

b Rule: *Words ending in a consonant retain the consonant before a suffix beginning with the same letter.*

sudden, suddenness; mean, meanness; cool, coolly

c Rule: *Words ending in* ch, sh, s, x *or* z (*the so-called hissing sounds*) *add* es *rather than* s *to form plurals of nouns and third person singular of verbs.*

church, churches; brush, brushes; gas, gases; tax, taxes; whiz, whizzes

In all of these words, it will be noticed that the addition of *es* adds another syllable to the pronunciation.

d Rule: *Words ending in a hard* c *usually add* k *to preserve the hard sound of* c *before a suffix beginning with a vowel.*

panic, panicky; picnic, picnicking

e Rule: *Some words ending in* f *or* fe *form their plurals by changing* f *or* fe *to* v *before adding* es.

life, lives; beef, beeves; loaf, loaves; but, *roof, roofs; belief, beliefs*

It will be noticed that the addition of *es* to any of these words does not add a syllable; likewise, it will be noticed that the pronunciation of each word clearly indicates whether *f* or *v* is used.

f Rule: *Words ending in* o *usually form plurals by adding* s, *especially if the* o *is preceded by a vowel.*

alto, altos; chromo, chromos; cameo, cameos

Some words ending in *o* preceded by a consonant add *es.*

motto, mottoes; potato, potatoes

Weak picturization. Words are often misspelled because the writer has never formed a true concept of the appearance of the word in script or type. Failure to recognize the word by sight leads to all kinds of confusion, such as those among *thought, though, through,* and *thorough,* and in words with *ei* and *ie* combinations. Even confusion between *per* and *pre* is more probably an error of sight than it is of pronunciation; so are misspellings such as *guage* and *gaurd* and *lonley* and *Britian.* Using double letters for single, and vice versa, likewise grows out of the failure to see words properly. Examples of such confusion are *watter* (water), *wats* (watts), *hapy* (happy), *conect* (connect), *dissapear* (disappear), *disatisfied* (dissatisfied),

shottgun (shotgun), *suden* (sudden), *setle* (settle), *sepage* (seepage), *cary* (carry), *devellop* (develop). Coupled with confusions of similar words, this same eye-failure accounts for such spellings as *sandwitch, bouyancy, preceed, superseed, proceedure.* No doubt a poor recognition of individual letters also allows such errors as those in which *s* is added to *y* without the change of *y* to *i*, as in *denys, applys, prys,* and *studys.*

Many errors of poor recognition probably are caused by the attempt to see only whole words and phrases instead of letters. Such an attempt may develop ability to read rapidly, but it may lead to poor spelling habits.

CONFUSION WITH SIMILAR WORDS. Coming from so many sources, the English language naturally has numerous homonyms, words of the same sound but of different meaning and usually different spelling.

Words alike in sound but different in meaning must be distinguished by memory. The technical writer may be confused by such couples as *ore, oar; principal, principle; site, sight, cite; chute, shoot; plane, plain; current, currant; aisle, isle; bale, bail; vane, vain, vein; sealing, ceiling;* and such variable forms of the same words as *instance, instants;* and *assistants, assistance.*

But much more confusing are the words of *nearly* the same sound but different meaning and spelling, such as *four, forty, fourteen; loose, lose; petition, partition; capital, capitol; compliment, complement; track, tract; counsel, council; angel, angle; florescent, fluorescent; stationery, stationary.*

CARELESS PRONUNCIATION. Slovenly pronunciation inevitably brings poor spelling. Subconsciously, the writer attempts to spell the sounds of a word as he utters them. If he slurs over a part of the word in pronunciation, he usually omits a letter or two in spelling; if he adds a sound, he is likely to insert extra letters. Some of the mistakes he often makes are *goverment* (*government*); *childern* (*children*); *sophmore* (*sophomore*); *atheletics* (*athletics*); *usally* (*usually*); *supprise* (*surprise*); *mathmatics* (*mathematics*); *Febuary* (*February*); *boundry* (*boundary*); *libery* (*library*); *valuble* (*valuable*); *parliment* (*parliament*); *strickly* (*strictly*); *quanity* (*quantity*); *hinderance* (*hindrance*); *lightening* (*lightning*); *buisness* (*business*); *labratory* (*laboratory*); *probally* (*probably*); *hunderd* (*hundred*); *mischievious* (*mischievous*); *tradegy* (*tragedy*); *predudice*

(*prejudice*); *umberella* (*umbrella*); *disasterous* (*disastrous*); *tremenduous* (*tremendous*); *prespiration* (*perspiration*); *rememberance* (*remembrance*); *irrevelent* (*irrelevant*); *beneficient* (*beneficent*); *preform* (*perform*); *generly* (*generally*); *artic* (*arctic*); *miniture* (*miniature*); *vacum* (*vacuum*); *ecentric* (*eccentric*); *furtherest* (*furthest*); *florescent* (*fluorescent*); *treasure* (*treasurer, treasury*).

Ignorance of sources. Many English words are spelled in accordance with the Latin, Greek, or other roots from which they came. Familiarity with these sources and thus with their derivatives would serve not only to increase the vocabulary (as discussed elsewhere in this chapter) but also to give assurance in spelling. Many of the words in the group just above are mispronounced (and therefore misspelled) because of failure to identify them with their sources.

A few of the words frequently misspelled because of lack of association between them and their sources are as follows:

auxiliary (L. *auxilium*, help, aid)
benefit (L. *bene*, well, good + *fit*, do)
candidate (L. *candidus*, white, pure, faultless)
data (L., plural; things given or agreed)
definite, definition (L. *finis*, end, boundary)
desiccate (L. *de* + *siccus*, dry)
dilapidated (L. *di-*, apart + *lapis, lapidis*, stone)
doctor (L. *doctor*, teacher)
dormitory (L. *dormire*, to sleep)
interest (L. *inter*, within, between + *est*, it is)
laboratory, elaborate (L. *labor*, work)
mortgage (L. *mors, mortis*, death + *gage*, pledge)
opportunity (L. *ob*, to, toward + *portus*, door)
optimistic (L. *optimus*, best)
prejudice (L. *praejudicium*, prejudgment)
privilege (L. *privilegium*, private law)
quantity (L. *quantus*, how much)
recognize (L. *re-*, again + *cognoscere*, to know)
separate (L. *se*, aside + *parare*, to prepare)
umbrella (L. *umbra*, shade, shadow)
arctic (Gr. *arktos*, a bear, constellation in the north)
chrome, chromatic (Gr. *chroma*, color)
chronic, synchronize (Gr. *chronos*, time)
phenomena (Gr., plural, those things observed; singular, *phenomenon*; cf. criterion, criteria)

sophomore (Gr. *sophos*, wise + *moros*, foolish)
amateur (Fr., one who performs for pleasure)
kindergarten (Ger., children's garden, school)
knave, knife, gnaw, knee (AS, words which originally had separate syllables expressed by the initial letter)
through, trough, though, thought (AS and ME, words which originally had sounds expressed by *g*, *h*, or both)
neighbor (Dutch, nearby farmer; cf. *boer*, farmer)

Some common English words frequently misspelled may be corrected by simple association with related common words.

accommodate (commode)
business (busy + ness)
carriage (carry + age)
complement (complete)
condemn (condemnation)
expurgate (purgative)
forehead (fore + head)
grammar (grammarian, grammatical)
marriage (marry + age)
paraffin (affinity)
professor (pro + fessor)
repetition (repeat)
ridiculous (ridicule)
visualize (visual)

However, a few words of English in long periods of usage have actually dropped syllables from some words; the writer must remember which words have thus been changed. A few examples are: *hindrance, encumbrance, suffrage, remembrance, entrance, disastrous.*

Unaccented initial syllables are pronounced so lightly that they are frequently confused and misspelled. Among them are *description* (not *discription*); *despair* (not *dispair*); *divide* (not *devide*); *enable* (not *inable*); *dilapidated* (not *delapidated*).

Unaccented syllables in other parts of the word frequently have to be memorized; they follow no rule, as *beggar, particular, humor, adviser, conqueror, labor, abhorrent, attendant, laudable, legible, center, acre, discipline, gelatine.*

Other causes. Some words are misspelled because of an imagined similarity to a word totally unrelated. An example is *similar*, which is often spelled *similiar*, evidently because of some fancied resemblance to *familiar*, though the words are

seldom actually pronounced alike. Possibly the same kind of resemblance, plus actual mispronunciation, accounts for the changing of *beneficent* to *beneficient*, with the fancied relationship directed toward *omniscient*, *proficient*, or *efficient*.

Words ending in *-ist* or *-est* are difficult to pronounce when they add an *s* to indicate the plural of nouns or the third person singular of verbs; consequently, the *s* is often incorrectly omitted in writing. A sentence like the following is not uncommon:

> Several test have been made by different geologist; each of them list the ores discovered.

Probably this error, which is becoming more frequent, is partly an outgrowth of the many *tourist* signs along the highway.

Failure to differentiate between *-ist* and *-est* is responsible for other errors, for example, *machinest*, or confusion between *purist* and *purest*.

From the discussion of difficulties for which no definite rules are possible, it must seem that spelling in English is helplessly and hopelessly chaotic, and that memory and observation have to carry the whole burden.

The appearance is all too true. The rules regularly listed and elaborated in English handbooks deal almost entirely with spelling of different forms of the same word. Only one deals with basic words. That one is the rule for choosing between *ei* and *ie*. Fortunately, it has few exceptions (when limited to the sound of *ee*), and lends itself to the familiar rhyme

Put *i* before *e*
Except after *c*.

Typical words to use as standards are *believe* and *receive*. The word *seize* constitutes about the only exception, since *either*, *neither*, and *leisure*, sometimes considered exceptions, have optional pronunciations and are thus not always sounded as *ee*. The words *weird* and *weir* are sometimes listed as exceptions, but in them the sounds of *ei* are not considered by all authorities to be the same as *ee*.

Words in which the combination *ei* has the sound of long *a* (*veil*, *freight*, *weigh*, *neighbor*, *obeisance*) usually place the *e* before *i*. Various other words, as *friend*, *view*, *fiery*, have some kind of special pronunciation, as do the *-ier* suffixes which indicate an approach to a *y* sound in such words as *soldier*, *glacier*, and *clothier*.

The writer who habitually does poor spelling must get at the roots of his trouble and correct his errors by eliminating their cause. If the cause is poor visual recognition, he must concentrate upon the appearance of the word; if the cause is inability to recognize individual letters, he must learn to see the letters and the syllables one by one; if the cause is unfamiliarity with the roots of the language, he must learn at least the principal sources in Greek and Latin; if the cause is an inability to fit word stems onto their suffixes, then he should study more thoroughly the rules already discussed here. But all of these correctives are useless unless the writer is willing to spend much time and effort for his own improvement.

Words frequently misspelled. The following list includes some of the words frequently misspelled in technical writing. The student should be prepared to spell and define any of them. They serve likewise as exercises in derivation and pronunciation.

abscissa
absorption
abutment
abutting
accelerator
accessibility
accessory
accidentally
accommodate
accumulate
acknowledge
acquitted
across
admissible
advice (noun)
advise (verb)
affiliate
aggregate
agreement
alignment
amateur
analyze
apparatus
apparent
applicable
appreciable
armature
ascertain
assumption
athletics
audience
automatically
auxiliary
avoirdupois
balance
believe
benefit
buoyancy
business
caisson
caliber (calibre)
calipers
calorimeter
cantilever
capacity
capillary
carburetor (carburettor)
casually
category
catenary
cathode
cavities
cellular
changeable
chassis
chute
cipher (cypher)
circuit
coalesce
coarse
coherence
collateral
combustible
committee
comparatively
complement
compliment
concede
conceive
condenser
conductor
conduit
conjunction
conscientious
considerable
controlled
converter
conveyor

coolly
corollary
correlate
corrugated
crucible
crystalline
cumulative
cycloid
cylinder
definition
deleterious
deliberate
depreciate
description
deteriorate
detriment
develop
diagrammatic
diaphragm
differential
dilapidated
diminution
disappoint
discrepancy
disintegrate
dissatisfied
distortion
ductile
durability
dynamic
eccentricities
efficacy
efficient
ejector
elaborate
elapse
electrolysis
elementary
elicit
eligible
eliminate
ellipse
embarrass
emitted
entropy
environment
epicycloid
equipped
equivalent
erected
erratic
especially
evaporator
evidently
exaggerate
excitation
exhauster
existence
experimental
explanation
facilitate
faculty
fallacy
feasible
fictitious
filament
forcible
formidable
fuselage
galvanometer
generally
government
graphically
gudgeon
harass
heterogeneous
hindrance
homogeneous
horizontal
illegible
illusion
imperceptible
impracticable
inadvertently
inaugurate
incidentally
increment
indefinitely
independent
indispensable
inductance
inflammable
initiate
inoculate
insolvable
instantaneous
insulator
intellectual
intelligence
interchangeable
interrupt
irrelevant
irresistible
irrigate
isosceles
itinerary
laboratory
laterally
likelihood
liquefaction
literally
longitudinal
lucrative
luminescent
maintenance
malleable
manageable
manufacture
meridian
metallic
miniature
miscellaneous
monotonous
mortgage
naturally
necessary
negligible
neutralize
normally
noticeable
obliterate
obstacle
occasionally
occurrence
omission

omitting
operation
opportunity
optimism
ordinance
ordnance
original
oscillation
oxidation
paraffin
parallel
particle
periodic
permanent
permeability
permissible
perpendicular
personnel
perspiration
pervade
petroleum
photometry
phraseology
planimeter
plausible
polariscope
porcelain
possess
potential
practicable
precedence
precedent
preparation
preventive
privilege
primitive
procedure
puncture
pyrometer
quantity
questionnaire
rarefy
ratchet
receptacle
regulate
reinforce
relative
repellent
repetition
requisite
residue
resilience
resistance
rotary
schedule
separate
serrated
similarity
simultaneous
specialty
spectacle
spherical
spontaneous
stagnant
superintendent
supersede
symmetrically
synchronous
systematize
tachometer
tangential
tenable
tendency
terminology
theoretically
thermoelectric
throttling
torsion
utilize
vacuum
variable
vernier
virtually
viscous
volatile
volumetric
wattmeter
weir
yield

Idiomatic phrases. Every language uses certain combinations of words that cannot be translated accurately into any other language. Indeed, an idiomatic phrase cannot be explained logically in English, since the meaning of the whole phrase is something entirely different from the added meaning of the separate words. Such expressions are called *idioms*,[34] since they are phrasal units peculiar to a language.

Thus Americans speak glibly of how they *turn on* a fan, *cut out* a light, or *pass up* an opportunity. From overwork they *give out*, and after successive failures they *give up*. Students *pay attention* in class; if they don't, they find trouble *to pay*.

[34] Cf. *idiosyncracy, idiomorphic, idiot* (Gr. *idios*, one's own, peculiar)

If accused of some wrongdoing, they don't *let on* that they know anything about it, even though the teacher does not *let up* until the students are *let down* or he has *let off* all his venom. He may even *let out* a yell. If given a task, the good student will *carry on* until he can *carry it out.* If forced to cease work for a time, he will *take up* where he *left off.* He will *settle up* his bills before he tries to *settle down.* If he is *well off,* he will have no trouble *at all.*

In ordinary greetings, the English speaker says, "How do you do?" The Frenchman says, "How do you carry yourself?" The German inquires, "How goes it?" All of them mean, "How is your health?" or "How are you feeling?" In America a book is written *by* an author. In Germany it is written *from* an author. In America one rides *on* the train or *in* the car; in Germany he goes *by* the train, bus, or car. In America, things are different *from* something else (formal); in England, different *than.*

Most idiomatic phrases involve prepositions. Some verbs or adjectives demand a particular preposition before a certain noun but a different preposition with a different noun. By their very nature, idioms cannot be organized for systematic study. They are felt rather than learned. The student must acquaint himself with general idiomatic usage, and with any idioms related to his profession. A few examples follow:

The engineer must be *able to* draw.
The engineer is *capable of* doing the work.
It is *difficult to do* this job.
They found *difficulty in doing* the task.
The linesmen *insisted on stopping.*
The transitman was *determined to finish.*
The book *treats of* many subjects and *deals with* several problems.
They *agreed with* each other but did not *agree to* the proposal.
He became reconciled *with* the landlord but never *to* the idea of moving.
Construction difficulties vary *from* each other *with* different seasons.
He was *surprised by* their entrance; they were *surprised at* his language.
The quarrel *between* the men was *over* the method.
The contractor is liable *to* the builder *for* damages.
Builders will not only *help to make* suitable adjustments but will also *assist in making* future plans.

Engineers do not *object to decorating* their structures but *refuse to weaken* them by mere ornamentation.

Sometimes listed as poor idioms are such phrases as these in italics:

The office was *too cluttered* for efficient work.
He was *very interested* in his work.

But here the difficulty is not a problem of idiom so much as of grammar. The participles *cluttered* and *interested* are used as adjectives but retain so much of their verbal connotation that they cannot be properly modified by adverbs of degree. The sentences quoted above have some semblance to this impossible statement:

He was *very forced* to move.

The sentences may be improved by adding *much* to the *too* or *very*:

The office was *too much cluttered* for efficient work.
He was *very much interested* in his work.

Adverbs of degree like *well* or *extremely* may be used more freely with past participles, if the combined meaning is logical. A few past participles, such as *tired*, have become so far removed from their verbal origin that they may be modified by an adverb of degree, as *very* tired or *too* tired. But the general rule is to avoid such structures.

Accuracy and force. Engineers sometimes believe that their writing needs dressing up. Accordingly, they indulge in all manner of pompous expressions, meaningless circumlocutions, tautological phrases, and hackneyed borrowings. Worse, they resort to general rather than specific words, and then of necessity clutter their sentences by numerous verbal restrictives which attempt to trim the general words down to the correct size.

The engineer should realize that his language takes strength from its directness and simplicity, just as he himself is more efficient if he carries with him only the necessary equipment. A flowery and wordy technical paper is as much out of place as a blueprint decorated by floral borders. Neither performs its duty efficiently, and both require extra time from the reader. Clear-cut familiar language is always best, with complicated words used only where they are more accurate than the simple. It is

better to use *reciprocating* than to say *having a part or parts with a to-and-fro motion,* even though *reciprocating* is of a more difficult vocabulary. It says more in a shorter space. However, it is much better to say *six valves, two elbows, and ten nipples, all ¾-inch in size,* than to say *the usual valves and other fittings for the regular size pipe,* even though the specific listing may require more words.

Such expressions as *stuff, very much, some kind of, somewhat of a, lots of, all such, sure, pretty good, in the neighborhood of, awful* (*bad, terrible*), *size up, concern* (*corporation*), *nowhere near, very different from,* indicate a slovenly thinker and writer. They leave the thought vaguely expressed, unless the vagueness is overcome by additional words.

Another bad habit is the use of two or more words to say what one word could say as well. Such phrases as *seldom ever, surrounded on all sides, universal everywhere, biography of his life, return back, gather together, cooperate together with each other, final termination, repeat again, free for nothing, combined together, completely eliminated, absolutely essential, consensus of opinion, past history, technical engineer, water hydrant,* and the like are wordy because they say the same thing twice. They are marks of the indecisive thinker.

Examples of jargon. Certain wasteful and overworked expressions have insinuated themselves into technical language so much that they deserve special notice. These words and phrases are called *jargon.*[35] The individual words are sometimes not objectionable, but their combinations with other words have been used slavishly for so long that the expressions have lost their vigor. Usually their sins include also wordiness, since more definite words can give the meaning more economically. But the worst of their faults is that they exhibit the writer as one mentally too lazy to make up his own phrasing. Technical papers are often filled with threadbare clichés and trite circumlocutions, simply because these phrases come without effort. Some writers actually believe the phrases are high sounding or literary. They might as well insist on using broken down shoes because such bootery is comfortable while the wearer stands still. They might as well buy a wornout bearing because it slips easily

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[35] *Jargon* as here used is in the sense employed by Sir Arthur Quiller-Couch; that is, *jargon* may be defined as any word or phrase stereotyped into the language by frequent use, especially if the word or phrase is a part of a wordy or useless construction.

onto the shaft. No amount of leftover verbiage can take the place of vigorous, well chosen phrases.

Some of the most common of these objectionable words and phrases are considered here. The student should add to them his own list of jargon and then start a systematic elimination of it from his writing and speaking.

CASE. The unfortunate word *case* is perhaps the greatest single source of jargon. It is unfortunate in that it is a homonym within itself; that is, two words with the same spelling and pronunciation have come into English from two widely different sources and have two totally different meanings. One *case* is derived from the Latin *cadere,* meaning *to happen* or *to occur.* Thus this *case* means a *happening* or an *occurrence*; naturally, such a broad word may be used in a multitude of conditions. The other *case* derives from the Latin *capere,* meaning *to hold.* Thus the English word means *container* or *box.* This double meaning gives rise to confusion and ludicrous usage.

But the chief offender is the "happening" *case,* which comes in several phrases, all of them trite and wordy.

in many cases (often, frequently)
in some cases (sometimes, occasionally)
in most cases (usually)
in case (if)
as is the case (as is true)
in each case (each time)
in other cases (sometimes)
such is the case (it is true)
in this case (here)
in all cases (always)

This meaning of *case* is accurately used to describe particular legal, medical, or pathological problems; in such meaning it is not objectionable. Otherwise, it should always be used with caution, or, better, not at all.

AS TO. Instead of using a simple *about,* some writers make their sentences more vague by using *as to.*

He said nothing *as to* his plans. BETTER: He said nothing *about* his plans.

The sentence using *as to* is virtually impossible of grammatical analysis, whereas the substitution of *about* makes clear the syn-

tactical relationship. Many other jargon phrases have the same effect on the sentence structure.

WITH REGARD TO, IN REGARD TO, AS REGARDS. Much like *as to,* but worse because more wordy, are the expressions *with regard to, in regard to,* and *as regards.*

> He gave no figures *with (in) regard to* the cost of the bridge.
> BETTER: He did not indicate the cost of the bridge.
> *As regards* balance, this is one of the best motors made.
> BETTER: This motor is as well balanced as any other; or, This motor is better balanced than most others.

In these sentences the basic statement is so broad that a part of it must be removed. The function of the *regards* phrase is to take off the surplus. Other examples of jargon occur for the same reason. In the first sentence, *He gave no figures* says much more than it eventually wishes to say. In the second, *this is one of the best motors made* is entirely too broad. The motor may have been totally unsatisfactory in all qualities except balance.

AS FAR AS [SOMETHING] IS CONCERNED. One of the most objectionable of these restrictors is the familiar *as far as [something] is concerned.* It is always attached to a statement that covers too much ground. Its purpose is to trim that statement down to the narrow meaning the writer had in mind.

> He made low grades *as far as mathematics is concerned.*
> BETTER: He made low grades in mathematics; or, He flunked algebra.

In the first of these sentences the general inference is that the student made low grades on all subjects; but the jargon tagalong reminds the reader in an ambiguous way that the student may actually have made A-plus on all subjects except mathematics. The same fault lies in these sentences:

> This is an economical engine *as far as fuel is concerned* (it may use a gallon of oil in an hour).
> The newspaper is neutral *as far as the city election is concerned* (it may be violently partisan in national politics).
> The house is all complete, *as far as the outside is concerned* (the inside may not have been touched).
> *As far as the policy is concerned,* the committee has done well (the people who administer the policy may all be crooks).

STANDPOINT, VIEWPOINT. Closely allied to the *concerned* phrases are those built around *standpoint* and *viewpoint*.

From the *standpoint* of the engineer, mathematics is an important subject.

BETTER: Mathematics is important to the engineer; or, The engineer should know mathematics.

From the *viewpoint* of the average man, tension, compression, shear, and torsion are meaningless words.

BETTER: Tension, compression, shear, and torsion mean nothing to the average man; or, The average man knows nothing of tension, compression, shear, and torsion.

ALONG THIS LINE, ALONG THE LINES OF. Few words have been subjected to such abuse as the familiar word *line* and the phrasal companions it drags along with it. Like most of the other expressions here considered, it represents a weak attempt to fill gaps in the thinking or writing of the author. The use of *line* to designate a business or profession is a sign of slovenly writing habits.

He said nothing further *along these lines*.

BETTER: He did not mention (or discuss) it further.

ON THE PART OF. Possibly originating in legal documents, which are notoriously wordy, the phrase *on the part of* is another of the weak expressions called jargon. It is vague and awkward.

The design of tunnels calls for exact skill *on the part of* the engineer.

BETTER: The design of tunnels requires skillful engineers; or, The engineer must be accurate if he is to design tunnels; or, Tunnel design requires accuracy.

IS FOUND. The useless phrase *is found* must be a hangover from high school. Usually it may be corrected by omitting *found*.

On the north side of the road a high bank *is found*.

BETTER: On the north side of the road is a high bank.

Several discrepancies *are found* in the bids.

BETTER: The bids have several discrepancies.

PURPOSES. Often the word *purposes* is used where it is not necessary and where it makes no contribution to the thought.

The house is used for residential *purposes*.

BETTER: The house is a residence.

The canal was dug for drainage *purposes*.
BETTER: The canal is for drainage.

PROPOSITION. Another of the all-encompassing words is *proposition*, used to name anything from a problem child to the latest model of car. Properly, its meaning is limited to "those things which are proposed." Usage beyond that becomes jargon; the word becomes high sounding but meaningless.

FIELD. The airy nothingness of *case* has a close second in the ubiquitous *field*; it is used to describe the *field* of engineering, the *field* of endeavor; just as it may refer to the *field* of a magnet, the *field* of an electric current, or a *field* of peanuts. Magnets, electric currents, and peanuts have definite meanings for the word. Less definite meanings are jargon.

PHASE. Like *field*, *phase* is much misused. Accurately, it means relative aspect, usually based on a time relation, as the *phases* of the moon or a three-*phase* current. Its use in any spineless meaning of *part* or *division* is to be avoided. It should be limited to its definite meanings. Both *phase* and *field* have precise meanings for the engineer; he should not be confused by their use in other meanings.

He is studying in the *field* of chemistry; he has taken up several *phases* of organic compounds.
BETTER: He is studying chemistry; he has already taken up the qualities of several organic compounds.

TRANSPIRE. Though the word *transpire*, in the sense of *occur* or *happen*, has forced itself into the English language, it is better used in its basic original sense. Its sonorous roar cannot make its meaning any more clear than plain *happen*; besides, it does not actually mean the same. Consult the dictionary for the meaning of this word and of others from the same stem.

MORE OR LESS. In the sense of *about*, *nearly*, or *approximately*, the phrase *more or less* may serve a useful purpose in presenting material which is necessarily approximated, as in discussion of inventories or real estate. But the phrase used as a direct modifier is inaccurate and objectionable.

The mixture was *more or less* saturated with oil.
BETTER: The mixture was nearly (or 90%) saturated with oil.

NATURE, CHARACTER. The words *character* and *nature* are frequently pure jargon of the worst kind in technical writing; that is, they are unnecessary.

> Because of the sandy *nature* of the soil and the lumpy *character* of the lime, they do not go well together.
> BETTER: The lime is too lumpy to mix well with the sandy soil.

Miscellaneous errors. The words *type* and *quality,* properly nouns, are sometimes misused as adjectives, as in

> The best *quality* fertilizer requires the highest *type* ingredients.

Pronouns *which* and *this* are often erroneously used without definite antecedents (discussed under *Vague Reference* elsewhere in the chapter).

Fix in the sense of *to repair* is becoming more common in colloquial speech, but it has no place in formal writing.

The expletives *there* and *it* usually encourage weak sentence structure and repeated usage (discussed under *Expletives* elsewhere in the chapter).

The noun *shape* is frequently and erroneously used to mean *state* or *condition.* Its meaning should be limited to *form, aspect, proportion,* or *outward contour.*

Due to phrases are often misused without a definite noun to be modified. The expression so used is grammatically incorrect (discussed under *Dangling Modifiers* elsewhere in the chapter).

The Latin abbreviation *etc* is often misspelled *ect* and is more often used unnecessarily. The actual purpose of the expression, though the writer may not know it, is to act as a cloak for hazy language. It actually descends to *&c* occasionally.

Colloquial usage may permit *while* to replace *though, although, whereas,* or *and* as a connective; but its real meaning is limited to the relationship of time. It should be so used.

> *While* copper is an excellent conductor, silver is even better.
> BETTER: *Although* copper is an excellent conductor, silver is even better.

The noun *reason* is wrongly used in sentences where it is the subject of the predicate *is because.* In formal writing the verb *to be* (*is, are, was, were*) must always link its subject to an adjective, substantive (noun or pronoun), or substantive clause.

A clause introduced by *because* is always adverbial in significance. It cannot therefore properly be used as a predicate with any form of the verb *to be*. Like *due to*, this error is especially likely to occur in expository writing, which tells why things happen.

The phrase *the fact that* can often be shortened or eliminated.

Simple diction. As has been said in the discussion of paragraphs, the engineer must present his information in phraseology understandable to his readers. By his choice of words he can direct his discussion to the average understanding of the group which will see his material.

It is possible to write quite acceptable prose in words of one syllable, expressing ideas which surely are no reflection on the intelligence of any reader. Some writers have performed such invigorating exercises, with surprisingly readable results. For example,

> And so, if you would speak or write of the prime facts of life—how things come to be and how they grow and change, such as plant life or how beasts and birds live, strange parts of the earth, the truths of seas and stars, the rains, the tides and that sort of thing, short words make it all the more clear. There is the same need to use words that are well known when you tell of the laws that rule the ways of light and heat, what things are made of, and how bare force may be put to work. For these truths are of such great use to us in our lives that they should be put in the reach of all.
>
> The crude man of the wilds "sees God in clouds or hears Him in the wind." For those are the fierce, big things that make men fear and stand in awe. But the wise men of our time mark the hand of God quite as much in small things, though they know now that, in point of fact, there is no such thing as size. That is, small things are great; for it is in and through them that what it is which runs the world acts—in seed and sperm and cell, in gene and germ, in mere specks of force that whirl at swift speed in wee rings, or pulse in rays and waves.
>
> These small things are all blocks of the stuff of which the world is built. And so why swathe such facts in a maze of set speech forms too hard for the man in the street to grasp? Great minds do not fear to use plain speech. For, like those small bits of life and force, short words, too, are great.[36]

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[36] Gelett Burgess, *Short Words Are Words of Might*, pp. 4-5

Many of the engineer's words are of more than one syllable, but he can at least gain respect for short words used in a vigorous fashion.

The following selection is a part of a popular book of instructions on the use of farm machinery. It is written to convey information in a simple but graphic manner. Without oversimplifying, it makes wide use of one-syllable words. Yet the total portrayal is clear and adequate.

> The modern hammer mill is designed to grind practically every type of feed, including small grain, shelled or ear corn, fodder and hay, to the size best adapted to the feeding purpose for which it is intended. With the wide variety of screens available for present-day mills, feeds may be ground to any practical degree of fineness ranging from extremely fine meal or flour to coarse roughage.
>
> Two units make up the hammer mill. The material to be ground is fed into the chamber of the mill where the hammers, revolving at high speed, cut it in mid-air, throw it against the breaker bars to be picked up and recut until it is reduced to particles small enough to pass through the screen which determines the fineness of the grinding. As the ground material passes through the screen, a suction fan draws it from the mill and forces it through the blowpipe into the feed collector for final delivery to sacks, bins, or wagons.[37]

The specimens of technical articles in Chapter 6 as well as the extracts in Chapter 1 will also illustrate the varieties in style which technical writers must use in appealing to different classes of readers.

Exercises

A Without dictionaries, distinguish between the similar words in the following list:

quite, quiet; principle, principal; advice, advise; capital, capitol; caliber, calipers; casual, causal; compliment, complement; efficacy, efficiency; practical, practicable; personal, personnel; prophecy, prophesy; repetition, reputation; respectively, respectfully; simultaneous, spontaneous, instantaneous; stationery, stationary; statue, statute, stature; villein, villain; sit, set; persecute, prosecute; ordinance, ordnance; most, almost; marital, martial; loose, lose; ingenious, ingenuous; healthy, healthful; formerly, formally; enormousness, enormity; eminent, imminent; duel, dual; disinterested, uninterested; credible, creditable, credulous; council, counsel;

[37] John Deere, *The Operation, Care, and Repair of Farm Machinery*, Deere and Company, pp. 162-163

continual, continuous; climatic, climactic; cite, site, sight; affect, effect; access, excess; accept, except.

B Without dictionaries, give the general meaning common to all words in each of the following groups; then take each word separately and give its particular meaning. Check your findings.

blow, hit, rap, tap, punch, thrust
balloon, airship, dirigible, monoplane, biplane, hydroplane
declare, affirm, signify, denote, imply, indicate
mend, repair, correct, better, ameliorate, rectify, elaborate
depict, draw, design, sketch, paint
author, journalist, essayist, reporter, hack, editor
brief, short, concise, curt, succinct, terse, trenchant
accurate, definite, concrete, precise, correct
appraise, assess, rate, measure, meter, survey

C Using dictionaries, find the origins for the following words:

electricity; vandal; point-blank; vertical; converse; zircon; worsted; recalcitrant; prerogative; lunatic; gladiolus; dynasty; cynosure; crucible; tandem; quinsy; surd; algebra; swap; vignette; filibuster; gradient; granite; nice; salute; thesis; topic; curfew; curriculum; sabotage; pantaloon; fusel oil; deliberate; ruminate; torrent; arduous; armature; fascinate; halcyon; pachyderm; protocol; sewer; tally; volley; zenith; kodak; lodge; parcheesi; obstreperous; nucleus; mountebank; guillotine; hiddenite; jeopardy; launch; lavish; platoon; quotation; resort; sarcasm; essence; guerilla; journey; meniscus; polonium; rankle; trite; valence.

D Improve the diction and construction in the following sentences:

1 The engineer was only acquainted with one type dam, due to his long service in one state.
2 Giving the flywheel a quick turn, the engine was quickly started, though usually it was a tough proposition.
3 Owing to the sharp declivity of the rocks, it was assumed that the ore had developed along the same lines as in other areas.
4 The engine was different than anything he had ever seen, as far as the valves were concerned.
5 The company made no predictions as regards the ability to pay dividends in the future.
6 Labor relations are a ticklish proposition from the standpoint of the manager.
7 Correct qualities of oil require close attention on the part of the stillman.

8 On the left of the doorway a large lathe is found; it is an important factor in making crankshafts.
9 The world we know has been made by the engineer as far as its physical aspects are concerned.
10 Scoring is where inadequate lubrication causes the piston to scrape the walls of the cylinder.
11 Due to his long training along the lines of bridge construction, he ought to know how to make buildings for manufacturing purposes.
12 He is very interested in engineering, owing to the fact that he had several relatives working in different phases of engineering.
13 In all cases, it is better to have a clear understanding in regard to the responsibility of the contractor as to quality of materials.
14 While many engineers hesitate to speak in public, others consider it an opportunity to explain the human phases of different fields of engineering.
15 Many people have sought a definition as to electricity, but no one knows just what it is.
16 The students' laxity is due to poor instruction in many cases.
17 Most all automatic stokers are controlled by some type thermostatic proposition.
18 There are some boilers which use injectors and some which use water pumps.
19 The engine goes around the curves very rapidly; this causes the track to need steep banking for balancing purposes.
20 Many workmen lost their jobs, due to model changes and revised working schedules.
21 Losing one's job is often due to model changes and is no reflection as regards one's efficiency.
22 Technological unemployment is workmen being laid off due to improved manufacturing methods.
23 At the present time, owing to shorter working hours, higher wages, etc, workmen have more time for recreation purposes.
24 Diesel locomotives generate their own electric power, which makes them different than the ordinary electric engine.
25 Flash point is to find out how hot the oil must be for the vapor to ignite when exposed to an open flame.
26 A very diffused mixture of sludge and water are found in the sewer, causing complex reactions.
27 Many phases of this problem are important elements in the explanation of the factors of the situation.
28 This company makes a nice type generator, one of the best of any concern now in business.

29 There is some variation in the consensus of opinion as regards the desirability of repeating again the program of last year.
30 One party believed that a filter plant was absolutely essential, but the other engineer believed it was a minor factor for that type sewer system.
31 The rolling character of the land is one of the elements of a satisfactory watershed in most all instances.
32 He expects to enter some phase of the business world, owing to his father's large experience.
33 He stopped too near the water hydrant was why he was arrested; it cost him a pretty good sum of money.

CHAPTER 3

Mechanical Details

THIS CHAPTER surveys and summarizes the following subjects: (1) punctuation, (2) abbreviations, (3) hyphenation, (4) writing of numbers, and (5) capitalization. The rules under these headings are intentionally confined to those usages which especially concern the technical writer.

Punctuation in Technical Writing

Proper punctuation is made easier if one understands the purpose of punctuation. It is a device for helping the writer to convey his meaning to the reader. It should be looked upon not as an arbitrary custom designed only to annoy the writer, but as a valuable aid in composition, something to be utilized to the writer's advantages. If the true function of punctuation is not appreciated, the rules are followed only, slavishly and unintelligently; if it is appreciated, they become slaves of the writer, ready to serve as he wills in the important business of making his meaning clear. Few rules of punctuation are ironclad; most of them are elastic and adaptable. Punctuation is an ingenious tool, the proper use of which makes for clarity.

Marks of punctuation. The common marks of punctuation and their uses are listed below. The section mark (§) applies to the numbered divisions in the section on Rules for Punctuation, page 114 ff.

Apostrophe

1 Omission of letters, **§16a**
2 Plural of letters and figures, **§18**
3 Possessive case, **§19**

Colon

1 Introduction to a series, **§14c** and **§22c**

2 Long or formal direct quotations, **§20c**
3 Salutation in a business letter, **§21**

Comma

1 Absolute expressions, **§3**
2 Appositives, **§5**
3 Connectives, **§12b** and **§12c**
4 Independent clauses of a compound sentence, **§12**
5 Introductory expressions, **§14**, **§20b**, **§20d**, and **§20e**
6 Addresses and dates, **§4**
7 Numbers of five or more digits, **§15**
8 Footnotes and bibliographical items, **§11**
9 Separation of parts of a sentence liable to confusion, **§6**
10 Separation of subordinate clauses from main clause, **§9**
11 Series of words, phrases, or clauses, **§22a**
12 Short informal direct quotations, **§20b**, **§20d**, and **§20e**

Dash

1 Abrupt break in the structure of a sentence, **§2** and **§17**
2 Appositives, **§5**
3 Introduction to a series, **§22c**
4 Introductory expressions, **§14a**
5 Parenthetical expressions, **§17**

Exclamation point

Exclamatory words, phrases, or sentences, **§10**

Hyphen. See pages 133 to 138.

Interrogation point

Interrogative words, phrases, or sentences, **§13**

Parentheses

1 Break in the continuity of a sentence, **§17**
2 Numbers indicating members of a series, **§17**

Period

1 Abbreviations, **§1** and pages 127 to 132
2 Declarative or imperative sentences, **§8**

Quotation marks

Quotations, **§20b**, **§20d**, **§20f**, and **§20g**

Semicolon

1 Independent clauses of a compound sentence, §**12**
2 Members of a series, §**22b**

Uses of marks of punctuation. The purposes of punctuation and the various kinds of marks which carry out these purposes may be summarized as follows.[1] Again, the section mark (§) applies to the numbered divisions in the section on Rules for Punctuation, page 114 ff.

To introduce

1 Series, formal—colon, dash, §**22c**
2 With introductory expressions, such as *namely, viz, i.e., e.g.* —preceded by comma, semicolon, dash, or colon; followed by comma or dash, §**14a**, §**14b**, and §**14c**
3 Quotations
 (a) Informal—comma, §**20b**
 (b) Formal—colon, §**20c**

To enclose

1 Absolute expressions—commas, §**3**
2 Appositives—commas, dashes, parentheses, §**5** and §**17**
3 Parenthetical expressions—commas, dashes, parentheses, §**17**
4 Quotations—quotation marks, §**20a** and §**20f**
5 Explanatory phrases with quotations, such as *he said*—commas, §**20d**
6 Unfamiliar terms or terms to which attention is directed—quotation marks, §**20g**
7 Titles of books or articles—quotation marks, §**20g**

To separate

1 Independent clauses of a compound sentence, §**12**
 (a) Without connective—semicolon, §**12a**
 (b) With adverbial connective—semicolon, §**12b**
 (c) With coordinating connective, *and, but, or, nor*—comma, §**12c**
2 Dependent clauses of a complex sentence, §**9**
 (a) Adverbial clauses—comma, §**9a**

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[1] For a suggestion about the functional classification of the rules for punctuation, the authors are indebted to *College Writing*, by John C. French and Paul M. Wheeler, Harcourt, Brace and Company.

   (b) Non-restrictive elements—comma, **§9b**
   (c) Restrictive elements—no punctuation, **§9c**
3 Series, members of
   (a) Single words and short elements—commas, **§22a**
   (b) Longer elements—semicolons, **§22b**
4 Parts of a sentence liable to confusion—commas, **§6**
5 Addresses and dates—commas, **§4**
6 Numbers—commas, **§15**
7 Footnotes—commas, periods, **§11**

To terminate

1 Sentences
   (a) Declarative—period, **§8**
   (b) Interrogative—question mark, **§13**
   (c) Exclamatory—exclamation point, **§10**
2 Quotations within a sentence
   (a) Declarative—comma, **§20e**
   (b) Interrogative—question mark, **§20e**
   (c) Exclamatory—exclamation point, **§20e**
3 Abbreviations—period or no punctuation, **§1**
4 Titles of books or articles—no punctuation, **§23**

Uses of the apostrophe

1 Possessive case, **§19a**
2 Possessive with gerund, **§19b**
3 Possessive in idiomatic expressions, **§19c**
4 Plural of letters and figures, **§18**
5 Omission of letters, **§16a**

Rules for punctuation in technical writing. One general direction should be noted: punctuate sparingly. When in doubt, "Don't!" Modern usage, especially in technical writing, sanctions economy in the use of marks of punctuation. Consider the specific directions and examples which follow.

1 Abbreviations

Use no period after the abbreviation of a technical term unless the abbreviation might be confused with a word in common use or might not be immediately recognizable. Use a period after abbreviations of non-technical words where usage demands it. See Rules for Abbreviations, page 127, and List of Abbreviated Words, page 129. As a safe guide for the punctuation of

abbreviations, the student may rely on the usage as recorded in the list, p. 129. Entire uniformity or consistency among technical writers is not to be expected in so fluid a thing as usage in the handling of details of English expression. Examples:

in.	inch
at. wt	atomic weight
f.o.b. (fob)	free on board
avdp	avoirdupois
cm	centimeter
p.m.	afternoon
viz. (viz)	videlicet

2 Abrupt break in the structure of a sentence

Use a dash, as in the following example.

> Could not some organization undertake to coordinate the research problems under investigation at the various university laboratories—some degree of mutual checking of results is not undesirable—and thus to expedite progress on all fronts?

3 Absolute expressions

Absolute expressions are set off by commas. The commonest form of absolute expression is a noun modified by a participle.

1 These preliminary studies having been made, we proceeded at once with our main investigation.
2 The dry-vacuum pumps and the hot-well pumps are steam-driven, the exhaust steam from these pumps being discharged into the feed-water heater.

4 Addresses and dates

Items in addresses and dates should be separated by commas.

1 5 Wall Street, New York, N. Y., U. S. A.
2 During the year 1940 he was in failing health, and on February 14, 1941, he died.
3 I returned to England in June, 1939.

Adverbial clauses. See §9a.

Ambiguity, to avoid. See §6.

5 Appositives

Appositives, or expressions which repeat an idea in other words, are enclosed in commas (or, less frequently, dashes).

1 That oldest textbook of science in the world, Euclid's *Elements of Geometry*, has been popularly held for centuries to be the very model of deductive logical demonstration.
2 The heights of any points, such as summits and bench marks, are given on the map in figures.

Awkwardness, to avoid. See §6.

Bibliographical items. See §11.

Business letter, formal parts of. See §4, §7, §21.

Chapter headings. See §23.

6 Clarity

Use a comma to separate parts of a sentence otherwise liable to confusion, ambiguity, or awkwardness. The practical effect of this rule is to compel the reader to make a slight pause at the point where a slight break occurs in the thought of the sentence. It is not safe, on the other hand, to regard pauses as a basis for punctuation, since many pauses are self-evident and need no punctuation.

CONFUSING: Before this production of synthetic dyes was limited to a few firms.
CLEAR: Before this, production of synthetic dyes was limited to a few firms.
CONFUSING: In the valley below the dam is regarded as a menace to life and property.
CLEAR: In the valley below, the dam is regarded as a menace to life and property.

Complex sentences. See §9.

7 Complimentary close in a business letter

Use a comma, as in the following examples.

Very truly yours,
Yours respectfully,

Compound sentences. See §12.

Confusion, to avoid. See §6.

Dates. See §4.

8 Declarative and imperative sentences

Use a period after a declarative or an imperative sentence.

1 The unique feature of the East River Station is its steam-producing equipment.
2 Do not depend on train schedules.

9 Dependent clauses of a complex sentence

As a rule a comma is used to separate a subordinate clause from a main clause, especially if the subordinate clause precedes.

9a An adverbial clause preceding a main clause is usually set off by a comma.

Although the induction generator is a well-known piece of apparatus, its chief use has been in electric traction.

9b A non-restrictive clause or phrase is set off by commas. Non-restrictive elements are loose modifiers whose presence is not essential to the meaning of a sentence. Compare the rule for restrictive clauses or phrases, §**9c.**

1 The asynchronous generator, which is merely an induction motor driven at a speed above synchronism, has proved for many years an interesting object for study.
2 This incandescent coke, being in a non-oxydizing atmosphere, remains as a support for the charge.
3 This principle was discovered in 1895, when radio was unthought of.
4a Chemical engineering is concerned with processes in which matter undergoes a change in state or composition. (Restrictive relative clause)
4b Examples of organic chemicals based on olefins are synthetic acetone, ethyl alcohol, ethyl ether, and the vinyl resins, all of which were announced ten years ago. (Non-restrictive relative clause)

9c A restrictive clause or phrase is not set off by commas. Restrictive elements are close modifiers whose presence is essential to the meaning of a sentence. Compare the rule for non-restrictive clauses or phrases, **9b.**

1 That batch of mortar which occupies the least volume is the one in which the amount of water used is most nearly correct.
2 These comprise the factors which are incidental to the specific operation.
3 The shaft is free to swing in any direction within a case which encloses a ring or die surrounding the crushing roller.

4 We have authorized a report covering the whole course of the survey.
5 This process has all the advantages and none of the disadvantages possessed by earlier processes.

End of sentence. See §8, §10, §13.

Enumeration. See §22a, §22b.

10 Exclamatory sentences

Use an exclamation point after an exclamatory word, phrase, clause, or sentence.

> What an amazing economy has resulted from following the recommendations of your report!

Explanatory phrases with quotations. See §20d.

11 Footnotes and bibliographical items

Footnotes may appear (1) separately, at the bottom of a page in a book or of a column in a journal or (2) collectively, toward the end of a book or at the close of an article in a journal. A bibliography is merely a more formal or more elaborate arrangement of the same kind of information. Usage as to the presentation of such notes, including punctuation, differs somewhat among editors and publishers. For examples of typical practices, see Chapter 1, pages 30 to 32.

Formal parts of a business letter. See §4, §7, §21.

Headings of chapters. See §23.

12 Independent clauses of a compound sentence

The mark of punctuation which should be used to separate the independent clauses of a compound sentence depends on one or another or all of the following conditions: (1) the degree to which the clauses are separate in thought; (2) the degree of emphasis accorded to each of them by the writer; (3) the presence of a connective, either adverbial (*so, hence, therefore*) or coordinating (*and, but, or*). The following subheadings with examples apply to typical compound sentences.

12a *Without connective.* The semicolon is used between independent clauses which are not joined by a connective. The use of a comma in such a case is rarely permissible and results in the serious "comma fault" (see page 62).

WRONG: Ties are usually slender members, struts have larger lateral dimensions.

RIGHT: Ties are usually slender members; struts have larger lateral dimensions.

12b *With adverbial connectives.* The semicolon is used between independent clauses which are joined by an adverbial connective (*so, hence, accordingly, nevertheless, therefore, consequently,* etc). The use of the comma in such a position is rarely justified. Note that many technical writers use a comma after the connective.

1 As stated above, the wattless current flowing in the armature of the converter depends upon the relative strength of the armature and field ampere-turns; hence, it is dependent upon the excitation of the converter.

2 The company decided that considerable economy in operation could be secured by concentrating the power-generating units into one plant; consequently, plans were immediately drawn and a new power plant erected.

3 There are no "steps" in the speed gradation, because the position of the brushes on the commutator determines the speed; therefore, any rate of speed from zero to maximum may be had, and the gradations are imperceptible without the use of a speed indicator.

12c *With coordinating connectives.* A comma is usually used between clauses joined by the coordinating connectives, *and, but, or, nor.* If the clauses are short and similar in form, no punctuation is necessary. If the clauses are very long, or if they are internally punctuated with commas, the semicolon is used.

1 In dealing with heavy traffic it is of the utmost importance that it be kept moving, and the only excuse which the railroad man will consider valid for the absolute interruption of the flowing stream is the total loss of the roadbed and track.

2 There are various systems of paying workmen for labor, but in each one a fair price is expected.

3 When the laws of heating and of cooling are identical, then the part of the total heat supplied which becomes transformed into work is constant for the same previous compression; and this resulting efficiency is a function of the previous compression only when these other two phases, compression and expansion, completing the cycle, have likewise the same law.

4 The payroll was received and the men were paid.
5 The material arrived and the work was begun.

13 Interrogative sentences

Use a question mark at the end of an interrogative sentence.

> Is it practicable to build and operate such a plant on the Pacific Coast?

14a Introductory expressions (*namely, viz, i.e., e.g.,* and the like)

If an introductory expression is used before a word or phrase in apposition, it is preceded by a comma or a dash and followed by a comma or a dash.

1 The third subdivision, namely, purification by preliminary chemical treatment, leads to the process which will be given most consideration.
2 The remaining alternative has been adopted, i.e., direct pressure with balanced relief valves.
3 If the direction of the stress is oblique—that is, not normal or perpendicular—on any section of a body, the stress may be resolved into the tensile or compressive stress normal to that section.

14b If an introductory expression is used before an independent clause, it is preceded by a semicolon and followed by a comma. The introductory expression might introduce a new sentence if the importance of the material of the independent statement should justify it. For instance, the illustrative sentence 1 might be divided into two sentences, the second being introduced by "That is."

1 Conditions have so changed as to eliminate the heating question entirely in the smaller sizes; that is, manufacturing considerations dictate cases of such sizes that the transformers have abnormally small temperature size.
2 The general design of this truss was liberal in the sections of the main members; for example, there seemed to be 15 or 20 per cent more material than requisite for safe construction.

14c If an introductory expression is used before a list of particulars, it is preceded by a colon and followed by a comma.

1 Three different kinds of apparatus enter into this applica-

tion: namely, the dryer or distiller; the vacuum pump; the condenser.

2 The tunnel engineer has three main problems to deal with: viz., to support a tremendous weight over soft mud or quicksand, to open and maintain a clear passage through it, to drain it off and eliminate it altogether.

Members of a series. See §22a, §22b.

Nominative absolute. See §3.

Non-essential elements. See §9b.

Non-restrictive elements. See §9b.

Notes. See §11.

15 Numbers

Use the comma in numbers of five or more digits only.

1350 21,800 51,225 37,000,000 $2468.50

16a Omission of letters

Use an apostrophe to indicate a contraction or the omission of a letter.

isn't (is not), number'd (numbered)

16b Use a caret (‸) to indicate the omission in copy of a letter, word, phrase, or clause.

retained
The foreman was ‸ until the last details were completed.

17 Parenthetical expressions

Any adverb, short phrase, or short clause which modifies loosely or which interrupts the continuity of the sentence is enclosed by commas, dashes, or parentheses. Although these marks are generally interchangeable, the commas are commonly used for the shorter expressions. Longer expressions, and even short phrases which make an abrupt break in the structure, usually require either dashes or parentheses. Parentheses are often advantageously employed to enclose the figures in numbering a series of words, phrases, or clauses.

1 It must, however, be realized that additional experiments by different observers are needed to confirm these results.

2 Natural cement, as its name implies, is made from rock as it occurs in nature.
3 The distinction, and it will become important in the future, lies primarily in the location of the tracks and in the grades and curves.
4 In buildings where long spans—such as those in excess of fifty feet—are necessary, steel, due to its lightness in truss form, has the advantage over any other material.
5 The length of the walks—very nearly two miles—made a tramway system imperative for economical distribution of the slabs.
6 The maximum fiber stress allowed for the concrete in compression was 500 lb per sq in., which with spans of 3 ft 6 in. (varying down to 2 ft 2½ in. and never exceeding 3 ft 7¾ in.) and the assumed live load of 150 lb per sq ft made necessary transverse bars.
7 Observation of the service of rails and of other articles (shafts, axles, propeller screws, etc) indicated that local defects in the metal have a predominant influence on their endurance.
8 The gas- and vapor-filled groups of tubes comprise three general classifications, including: (1) the cold-cathode type; (2) the hot-cathode type with filament-heated cathode; and (3) the mercury-pool type employing arc discharge.

18 Plural of letters and figures

Use an apostrophe to form the plural of letters of the alphabet and of figures.

> Cross your t's and dot your i's; make your 7's and 3's more distinctly.

19a Possessive case

The possessive singular is formed by adding an apostrophe and *s* to a noun. Although some authorities favor the use of the apostrophe without the *s* after nouns ending in *s*, there is a growing tendency to allow no exceptions to the rule.

> the foreman's duty, William's letter, Mr. Williams's report, Mr. Jones's appointment, Lewis's record

If the plural of a noun ends in *s*, the plural possessive is formed by adding an apostrophe.

> the stockers' wages, the consulting engineers' opinions, the Strauses' benefactions, ladies' clothing

If the plural of a noun does not end in *s*, the plural possessive is formed by adding an apostrophe and *s*.

> the men's share, the People's Service Company

Do not use an apostrophe in the possessives *its, hers, ours, yours, theirs.*

1. The line carries its lightest load in the early morning.
2. Yours truly.

19b *Possessive with gerund.* A noun or pronoun which modifies a gerund (verbal noun) is in the possessive case, formed by adding an apostrophe and *s*.

1. The reason for the engine's skipping was soon discovered.
2. I am opposed to Jones's taking on this extra work.

19c *Possessive in idiomatic expressions.* Aside from such examples as would fall under (b), the names of inanimate things are not used in the possessive, with the exception of a few idiomatic expressions, especially expressions denoting time and measure.

> a year's progress, six weeks' salary, two months' vacation, a stone's throw away, ten minutes' ride, a boat's length, fifty cents' worth; *but* the base of the machine

Questions. See §13.

20 Quotations

Quotation marks are usually double inverted commas. Single inverted commas are rarely used, except for quotations within quotations (see **20f**).

20a Enclose all direct quotations in quotation marks.

> Mr. Jones then made the following observation: "The Office of Petroleum Coordinator is placing at the top of the list new exploration, wildcatting, and discovery operations."

20b A comma is used to introduce a short informal direct quotation.

> Mr. Travers added, "In thinking of the capacity of your boiler house, you may consider the chimney as the neck of the bottle."

20c A colon is used to introduce a long or formal direct quotation.

One of the Stevensons of Edinburgh, a family famous in engineering work for more than a century, said: "The duty of the engineer is twofold—to design the work and to see the work done."

20d Explanatory phrases, such as *he said,* interpolated in a quotation, are ordinarily enclosed by commas. The interrupting of the quoted matter is indicated by quotation marks at the end of the quotation preceding the explanatory phrase and at the beginning of the quotation following the explanatory phrase.

1 "This assignment is a tricky one," he continued. "You will have to keep on your toes."
2 "How much damage will it do us?" they asked.
3 "By George!" he exclaimed, exultantly, "That dam will stand anything."
4 "Reports should be short and definite," said the Chief; "but every statement must be based on a good reason, whether expressed in the report or not."

20e To terminate a quotation within a sentence, use a comma after a declarative quotation, a question mark after an interrogative quotation, an exclamation point after an exclamatory quotation.

1 "Don't take for granted that your client has knowledge of the subject," he warned us.
2 It might here be noted that the principle well known in explosive combination at constant volume, that "to a chemical mixture of air and gases there may be added large quantities of gas without altering the explosive properties of the mixture," is, by these experiments, extended.
3 The only question which arises, "Could the engine itself not have been designed to get back this wasted power?" must be answered in the negative.
4 "What a waste of effort!" was his only comment.

20f Use single quotes for quotations within quotations.

The speaker then continued as follows: "Before we can discuss adequately 'the making of industrial physicists' we must agree in our concept of that particular species."

20g Special uses of quotation marks are: to indicate that the enclosed words in an indirect quotation are the exact words of the source; to set off a technical term that may be unfamiliar

to the reader; to emphasize an expression to which special attention is directed; to enclose the title of a book or article mentioned in a sentence.

1 An example of the refinement of design in conveyor chain is the "Maximum chain" developed from the old "two and two" steel chains.
2 The term "free lighterage" means that the freight is to be lightered to points within the lighterage limits without any charge beyond the regular New York rates.
3 This change of condition is known as the "setting" of cement and is considered to be, in a measure, distinct from "hardening."
4 Many specifications require that a certain percentage "shall pass a sieve having 2500 holes per square inch."
5 When a previous treatise by the author was published under the title of "The Mechanical Engineering of Power Plants," it was suggested by one of his most gifted critics that the title should be amended because the book did not cover the power-plant practice which uses gas engines.

Restrictive elements. See §9c.

21 Salutation in a business letter

Use a colon, as illustrated below.

Dear Sir:
Gentlemen:

22a Series, members of

Commas are ordinarily used to separate the members of a series. Better usage retains the comma with *and* between the last two items of a series.

1 The loss by condensation, radiation, and friction would more than offset the gain.
2 The preparation costs are again subdivided into (1) formation expenses, (2) stand-by costs, (3) service costs.
3 The generating equipment has been enlarged by the addition of a General Electric, 17-stage, steam turbine, driving a 3-phase, 60-cycle, 11,000-volt generator.

In a series of modifiers used connectedly, in a cumulative and descriptive sense, and preceding the noun which they qualify, commas may be omitted.

We have installed three 600-hp Koerting double-acting two-

cycle gas engines, operating at 100 rpm, directly connected to a 400-kw Westinghouse a-c generator.

22b Semicolons are used to separate the members of a series if the items are long, or have marks of punctuation within themselves, or should stand out distinct from each other.

1 The effort of the Sanitary District will be to demonstrate (1) that there is a failure on the part of the Government to make proof, and, further, that the use of this water for the purpose of the preservation of life and health of the inhabitants of a large city is a use paramount to the use of the water for navigation; (2) that the slight (and, as we believe, improved) loss to commerce due to a lowering of 2½ in. is a matter of minor importance as compared with the preservation of human life; (3) furthermore, that as an offset to the slight injury to the lakes, the diverted water will facilitate and develop commerce of vast importance.

2 This should suffice, for it is to be borne in mind that the electric heat is cumulative, and is added to material already close to the fusion point; that the time or capacity element is the one to be affected by the quality of the current; that if the volume of current is small, it simply takes a longer time for it to supply the deficiency for smelting a given quantity of semi-fluid material than it will take when the volume of current is larger.

3 It has accomplished its chief purpose by securing compensation to the injured workman and his dependents; its method of operation has proved comparatively simple and inexpensive; it has not proved a ruinous burden to employers.

22c If the members of a series are long or formal or internally punctuated, the series is introduced by a colon or a dash, if any introductory punctuation at all is needed. (For absence of such punctuation marks, see §**22b**.)

The features shown on these maps may be arranged in three groups: (1) water, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) relief, including mountains, hills, valleys, and other features of the land surface; (3) culture (works of man), such as towns, cities, roads, railroads, and boundaries.

23 Titles of books or articles

Do not use a period after the title of a book, the center heading of a chapter, section, or paragraph. See also §**20g**.

1 A Card System for Mine Accounts
2 The Properties of Cement and Methods of Testing
3 Chapter IV Interior Wiring for Central Station Plants
(See also headings for chapters and sections in this book.)

Unfamiliar terms. See §20g.

Words in series. See §22a, §22b, §22c.

Use of Technical Abbreviations

Technical writers vary in their use of abbreviations. The rules and list which follow record the present usage of the best technical writers. The appearance of the page, the frequency with which a word is used, the purpose of the piece of writing, and the class of readers to which it is directed, all call for an exercise of the writer's judgment in the use of abbreviations.

Rules for abbreviation. The following rules apply only to the use of abbreviations in normal technical prose. In tabular statements, enumerations, headings, etc, and in such pieces of writing as a letter containing an order for goods, many shortened forms of words are permissible which would not be approved in a finished report or technical article. On the other hand, these rules permit a much wider use of abbreviations than is sanctioned in conventional, literary prose.

1 Use too few rather than too many abbreviations; when you are in doubt, write out the word. An indiscriminate use of abbreviations indicates slovenliness and may sometimes obscure the meaning. If an abbreviation is not at once understood by the reader of a technical article, he loses time in determining its meaning.

2 Use lower-case characters (small letters) for abbreviations. An exception to this rule is made in the abbreviation of capitalized words and of a few other words specified in the list on page 129. No general rule will cover all exceptions to the use of small letters for abbreviations. Students must be prepared to recognize variations in practice; *e.g.*, abbreviations for such words as *volume* and *number* in bibliographical references are sometimes written "vol., no." and sometimes "Vol., No."

1 p.m. (afternoon)
2 kw (kilowatt)
3 Btu (B.T.U.) (British thermal unit)

4 U. S. gal (United States gallon)
5 B. & S. gage (Brown and Sharpe gage)
6 NE (northeast)

3 For punctuation of abbreviations, see Punctuation, rule 1, p. 114, and List of Abbreviated Words, p. 129.

4 Use all abbreviations in the singular. Exceptions are *Bros.*, *ff*, *mss*, *pp*.

17 lb, 14 in., 15 oz, 8.9 cm, figs. no. 3 and 8

5 Abbreviate nouns only after definite numerals of quantity.

1 The power plant has a capacity of 450 hp; *but* The capacity of the power plant in horsepower is 450.
2 20 lb; *but* several pounds

6 Abbreviate *figure* and *number* when they precede a numeral.

No. 2 or no. 2 shaft; Fig. 3 or fig. 3

7 Abbreviate *company* in firm names, except where contrary to the company's approved form.

John Brown & Co.; *but* American Smelting and Refining Company

8 Use abbreviations, not signs, except in tabulations or drawings, to indicate feet and inches, or minutes and seconds of time. But signs are correctly used to denote degrees, and minutes and seconds of degrees. Examples follow.

1 14 ft 3 in.; *not* 14′ 3″
2 34 min. 5 sec; *not* 34′ 5″
3 10° 34′ 5″

9 Do not use the sign x for the word *by*.

8 in. by 12 in.; *not* 8 in. x 12 in.

10 Abbreviation of the names of the months is permissible, though better avoided. Except in memoranda, do not use figures to represent the months. The days of the week should not be abbreviated except in tabular headings. Do not use *st*, *nd*, or *th* with numerals.

March 10, 1942, *or* 10 March, 1942; *not* 3/10/42 *or* March 10th, 1942

11 Do not abbreviate abstract or descriptive words that have not become parts of a phrase instantly recognizable and generally accepted in abbreviated form.

1 horizontal return tubular boilers; *not* h.r.t. boilers
2 high-pressure cylinders; *not* h-p cylinders

12 Do not abbreviate an adjective which qualifies the name of a unit. Exceptions: *bhp* (brake horsepower), *ehp* (electric horsepower), *emf* (electromotive force), *ihp* (indicated horsepower), *mmf* (magnetomotive force).

boiler horsepower; *not* b.h.p. *or* b. horsepower

13 Do not abbreviate titles of courtesy, unless they are used with a full name.

1 Professor Ward *or* Prof. H. W. Ward; *not* Prof. Ward
2 The construction engineer authorized the report; *not* The const. engr. authorized the report.

14 Do not abbreviate the name of a city.

New York, Chicago, Kansas City; *not* N.Y.C., Chi., K.C.

List of abbreviated words. Usage is a matter of slow growth. Students should not be disturbed, therefore, at finding different usages among technical writers as to the presence or absence of periods after abbreviations. A general rule for the punctuation of abbreviations for technical words is stated on page 114. For certain words in common use, such as *agent, page, volume,* the period is retained by most writers (*agt., p., vol.*); however, in the official list of the American Standards Association, *yd, yr, pt, oz* are written without the period.[2]

absolute abs
acre spell out
acre-foot acre-ft
ad libitum ad. lib.
afternoon p.m.
agent agt.
air horsepower air hp
alternating current a-c (when used as a compound adjective)
American Society of Civil Engineers A.S.C.E.
American Society of Mechanical Engineers A.S.M.E.

[2] The foregoing Rules for Abbreviation and the List of Abbreviated Words are based on the American Standard for Abbreviations for Scientific and Engineering Terms, which was approved by the American Standards Association, March, 1941.

American Society of Testing Engineers A.S.T.E.
ampere amp
ampere-hour amp-hr
and so forth etc
and the following (Latin, *et sequentia*) et seq.
Angstrom unit A
armature arm.
assistant asst
atmosphere atm
atomic weight at. wt
avoirdupois avdp
barometer bar.
barrel bbl
Baumé Bé
bill of exchange b.e.
Birmingham wire gage Bwg
board feet (feet board measure) fbm
boiler horsepower boiler hp (not b.hp.) or bl hp
boiling point bp
brake horsepower bhp
brake horsepower-hr bhp-hr
British thermal unit Btu or B.T.U.
Brothers Bros.
Brown and Sharpe B. & S.
building bldg.
bushel bu
buyer's option b.o.
calorie cal
candlepower cp
cash on delivery c.o.d. or C.O.D.
cent c or ¢
center to center c to c
centigrade cent. or C
centigram cg
centiliter cl
centimeter cm
centimeter-gram-second (system) cgs
chapter chap.
chemically pure cp
circular mils cir mils
Civil Engineer C.E.
coefficient coef
company. See Rule **4.**
compare (Latin, *confer*) cf.
Construction Engineer Constr. Engr.
Consulting Engineer Cons. Engr.
continental horsepower cont hp
Contracting Engineer Contr. Engr.
cosecant csc
cosine cos
cost insurance freight cif (c.i.f.)
cotangent cot
counter-electromotive force cemf
cubic cu
cubic centimeter cc (liquid, meaning milliliter, ml) cu cm
cubic feet per minute cfm
cubic feet per second cfs
cubic foot cu ft
cubic inch cu in.
cubic yard cu yd
decaliter dal
decibel db
degree deg or °
Degree Centigrade C
Degree Fahrenheit F
Degree Kelvin K
Degree Réaumur R
department dept.
diameter diam
direct current d-c (when used as a compound adjective)
East E.
edition ed.
electric elec
electric horsepower ehp

Electrical Engineer E.E.
electromotive force emf
engineer engr.
et alia et al.
et cetera etc
Fahrenheit fahr or F
farad spell out or f
following ff.
feet board measure (board feet) fbm
feet per minute fpm
feet per second fps
figure, figures, fig. or Fig.
foot, feet ft
foot-candle ft-c
foot-pound ft-lb
foot-pound-second (system) fps
forenoon a.m.
for example (Latin, *exempli gratia*) e.g.
for the time being (Latin, *pro tempore*) pro tem.
free aboard steamer spell out
free on board f.o.b. (fob)
fusion point fnp
gallon gal
gallons per minute gpm
gallons per second gps
grain spell out
gram g
gram-calorie g-cal
hectare ha
hectoliter hl
hectometer hm
henry h
high-pressure cylinder spell out
His Majesty's Ship H.M.S.
horsepower hp
horsepower-hour hp-hr
hour hr
hundredweight (112 lb) cwt
ibidem (in the same place) ibid.
idem (the same) id.
inch in.
inches per second ips
incorporated inc.
indicated horsepower ihp
indicated steam power isp
Industrial Engineer I.E.
instant (the present month) inst
in the Year of Our Lord (Latin, *anno domini*) A.D.
kilocalorie kcal
kilocycles per second kc
kilogram kg
kilogram-calorie kg-cal
kilogram-meter kg-m
kilograms per second kgps
kiloliter kl
kilometer km
kilometers per second kmps
kilovolt kv
kilovolt-ampere kva
kilowatt kw
kilowatt-hour (kilowatthour) kwhr
last (the last month) (Latin, *ultimo*) ult.
linear lin
liter l
loco citato (the passage quoted) loc. cit.
logarithm (common) log
logarithm (natural) $\log_e$ or ln
low frequency current lfc
low-pressure l-p (as adjective)
lumen l
lumen-hour l-hr
lumens per watt lpw
magnetomotive force mmf
manager mgr.
manuscript ms (MS)
mean effective pressure mep
mean sea level msl
Mechanical Engineer M.E.
merchandise mdse.

Metallurgical Engineer Met. Engr.
meter, meters m
meter-kilogram m-kg
micro ampere mu a or μa
microfarad μf
micromicron mu mu or μ μ
micron mu or μ
mile spell out
miles per hour mph
miles per hour per second mphps
milliampere ma
milligram mg
millihenry mh
milliliter ml
millimeter mm
millivolt mv
minute min
molecular weight mol. wt
month spell out
namely (Latin, *videlicet*) viz.
National Electric Code NEC
North N.
note well (Latin, *nota bene*) N.B.
number, numbers no. (No.)
ohm spell out or Ω
ounce oz
page, pages p. pp.
passage quoted (Latin, *loco citato*) loc. cit.
pennyweight dwt
per spell out
percentage % or per cent
pint pt
potential drop spell out
pound, pounds lb
pounds per cubic foot lb per cu ft
pounds per square foot psf
pounds per square inch psi
power factor spell out or pf
Railroad, Railway R.R., Ry
revolutions per minute rpm
revolutions per second rps
secant sec
second sec
see vid. or v.
seller's option s.o.
series ser
sine sin
small letters (lower case) l.c.
South S.
specific gravity sp gr
specific heat sp ht
square sq
square root of mean square rms
stere s
superintendent supt.
switchboard spell out
tangent tan
tensile strength ts
that is (Latin, *id est*) i.e.
the same (the writer or the work last cited) idem
ton spell out
ton-mile spell out
United States gage USg
United States Ship U.S.S.
videlicet viz.
volt v
volt-ampere va
volume, volumes vol.
watt w
watt-hour whr
watts per candle wpc
week spell out
weight wt
West W.
which see (Latin, *quod vide*) q.v.
work quoted (Latin, *opere citato*) op. cit.
written afterward (Latin, *post scriptum*) P.S.
yard yd
year yr

Hyphenation of Technical Words

The matter of hyphenation is not a simple one. Rules have been formulated from time to time by editors, lexicographers, and engineering societies, but no agreement about the best usage has been reached. In actual practice, much must be left to the judgment of the individual, supplemented by observation of the usage of reputable writers of his own time. In doubtful instances it is often helpful to consult the latest and best dictionaries.

Use of the hyphen. The hyphen is used (1) to indicate the division of a word at the end of a line, and (2) to make clear a writer's intention in the use of compound words. The second of these uses only is discussed here. The presence of a hyphen between two words usually indicates that the expression has a slightly different meaning from that which would be conveyed if the words were written separately or if two words were united to form a pure compound word. More specifically, the absence or presence of the hyphen indicates varying degrees of intimacy between adjacent words: (1) If two words are merely juxtaposed, as "steam power," only a loose relationship between them is suggested; (2) if they are written with a hyphen, as "power-lathe," it indicates that they are intimately associated in idea without entirely losing their separate identities; (3) if they are written solid, as "horsepower," their separate meanings have been merged in a new single meaning. Many compounds have passed through these three stages in succession as their association has become increasingly familiar; for example, "railroad" was originally written "rail road," then "rail-road."

Rules for hyphenation. The following rules, accompanied by examples, are offered as an attempted formulation of the best modern usage in the writing of compound terms.

1 Use hyphens sparingly.

2 Be certain that your use of hyphens precisely indicates your meaning.

3a Use hyphens with adjective compounds preceding a noun. These adjective compounds may consist of

1 a noun + a noun (machine-tool)
2 a numeral + a noun (12-inch)

3 a letter + a noun (T-head)
4 a descriptive adjective + a noun (dry-blast)
5 a compound participial adjective (direct-connected)
6 a phrase compound (right-of-way)
7 a compound term made with a prefix or a suffix (semi-transparent break-away)

Study the following examples:

alternating-current system
anti-friction metal ring
blast-furnace operatives
bituminous-coal mine
boiler heat-transmitting surface
cast-iron follower-ring
central-station manager
coal-handling apparatus
combined high- and low-pressure turbine
connecting-rod thrust
constant-speed motor
constant-voltage mains
counter-current condenser
counter-sunk screws
cross-compound direct-connected engine
direct-current magnetic blow-out circuit
direct-current open-arc street-lighting plant
double-pole, double-throw, remote-control switches
dry-blast process
electric-light company
explosives-testing station
50-watt lamp
flat-rate system
four-story house
full-feathering type
full-load capacity
hard-burned bricks
high-frequency disturbances
high-speed mixed-flow turbo-generator
live-steam heater
machine-tool practice
motive-power equipment
multiple-cylinder engine
saturated-steam runs
75-horsepower engine
750-pound pressure
62.5-horsepower turbo-blower set
slow-speed engine
steel-pole aerial line
T-head valve stem
12-inch main
twenty 80-horsepower automobiles
variable-pitch propeller
watt-hour meter
wet-milling plant

3b Exceptions to **3a** occur:

1 when the adjective compound is written as a single word (overshot, fireproof, streamline)
2 when the adjective compound is a chemical term (sodium chloride)
3 when the meaning is perfectly clear without the hyphen (*power plant* economy, *machine tool* design)
4 when the first word of the series is an adverb ending in -ly (highly recommended practice)

4a Write as one word a compound noun or verb if it expresses singleness of meaning, if through long use each part of the term has lost its separate significance, or if the expression is entirely clear without the hyphen. Examples:

airplane	cutoff	quicklime
altogether	drydock	railroad
ashpit	eyebar	reheat
backfire	firebox	reroll
bedplate	fireproof	retest
blowoff	flywheel	reweigh
blueprint	footnote	setscrew
bulkhead	handbook	sinkhead
busbar	hardpan	staybolt
bypass	headstock	streamline
candlepower	horsepower	substation
carload	input	switchboard
cooperate	intake	today
countershaft	limewater	together
crankcase	nevertheless	voltmeter
crankpin	offset	wattmeter
crankshaft	orebody	wheelbase
crosshead	overflow	wristpin

4b But hyphenate a compound noun which is composed of two or more words each of which is a distinct engineering unit of measurement. Examples:

foot-candle	kilovolt-ampere
foot-pound-second	kilowatt-hour (or kilowatthour)
gram-calorie	meter-kilogram
gram-centimeter	volt-ampere
kilogram-calorie	
kilogram-meter	

5a Write separately the parts of a compound term if each word retains its identity and a certain degree of its normal accent, and if the meaning is brought out clearly when the parts stand as separate words. Examples:

air compressor	boiling point
all right	building site
angle iron	cast iron
bevel gear	cast steel
boiler room	circuit breaker

connecting rod
cylinder head
drafting room
drop test
end thrust
engine bolt
engine room
field data
fire tube
flash point
friction clutch
gas engine
gas producer
gas regulator
gas turbine
hot water heating
hot well
latent heat
machine shop
machine tool
open hearth
ore deposit
peak load
piston rod
power factor
power plant
pressure gage
printing press
pump shaft
railroad car
rod mill
rolling mill
sand bricks
shop order
slide rule
specific heat
spur gear
steam jacket
steam turbine
steam boiler
steam heat
steam piping
steam plant
step bearing
street railway
testing machine
twist drill
valve gear
water bath
water meter
water system
water tube
water works
wing strut
wiring system
worm gear
wrought iron
yield point

5b But the foregoing terms, if used as single modifiers, are hyphenated in accordance with rule **3a**. Examples:

piston-rod assembly
drafting-room payroll
open-hearth process
street-railway system
water-tube boiler

6 Hyphenate the parts of a compound term if they express a composite idea without entirely losing their separate meanings, or if writing the parts either solid or separately would be less clear.

buzz-saw
castle-nut
drop-forging
foot-pounds

heat-treatment	S-hook
I-beam	short-circuit
iron-molder	spring-washer
iron-saw	tail-skid
jet-condenser	take-off
kilowatt-hour	ton-mile
lightning-arrester	tool-steel
make-ready	T-square
right-of-way	U-bolt
set-up	vacuum-tube
	X-ray

7 Do not hyphenate words which stand in regular syntactical relation.

a newly installed motor, systems by alternating current, disturbances of high frequency, pressure of 750 pounds

8 Compound cardinal numbers from 21 to 99 should be hyphenated, whether used alone or as parts of larger numbers.

twenty-one, ninety-nine, fifty-three thousand

9 All words composing ordinal numbers should be joined by hyphens.

twenty-first, one-hundred-and-sixth

10a Do not hyphenate simple fractions unless they are used as modifiers.

three fourths of an inch, nine tenths of a mile; *but* a one-eighth share, a one-half interest

10b Fractions involving compound numbers follow **8** and **9**.

eight thirty-seconds, forty-seven ninety-sixths

10c Use hyphens with compounds beginning with half, quarter, eighth, etc.

half-dozen, quarter-section

11 Do not use the hyphen between numbers to express a range of measure or quantity.

5 to 7 cc; *not* 5-7 cc

12 Do not use the hyphen in simple compounds indicating points of the compass.

northeast, southwest; *but* north-northeast, south-southwest

13 If confusion in meaning is likely, use a hyphen to separate the prefix re- from the word to which it is joined.

re-treat, re-enter, re-anneal, re-erect, re-examine; *but* rebuild, refill

14 Use hyphens in abbreviations of hyphenated expressions.

a-c circuit (alternating-current circuit); ft-lb (foot-pound); *but* not in kva (kilovolt-ampere), va (volt-ampere), whr (watt-hour). Usage is not uniform.

Writing of Numbers

The following general rules for the writing of numbers, though they admit of exceptions depending on the nature of the article in which they are used, will serve as a reasonably accurate guide to the preferred practices in technical writing.

1 Use figures for 10 and for numbers over 10; spell out those under 10.[3] There are many exceptions to this general rule:

1a Always spell out a number at the beginning of a sentence or recast the sentence.

Fourteen men working six days completed the dam; *or* The dam was completed by 14 men working six days.

1b Do not spell out numbers below 10 when they are used (1) in a series of two or more connected or contrasted numerical statements in which some of the numbers must be numerals; (2) in a series of connected numerical statements where precision is implied; (3) in a paragraph or article where numbers are used freely throughout.

1 In this accident 8 men were killed and 16 or 18 injured.
2 We found that 9 men working 6 days with machine-drills were able to sink the shaft 12 ft, breaking 75 tons of ore.
3 At 300% rating, a boiler will deliver 180,000 lb of steam per hour and burn 8 to 9 tons of coal.
4 There are in all 9 intake and 9 discharge tunnels of cast-iron pipe, each 6 feet in diameter, a total length for the projected capacity of 4200 feet of pipe, all imbedded in concrete.

---

[3] But see the rule of the American Society of Mechanical Engineers: Spell out all numbers from one to twelve.

1c When one number follows another immediately, spell out one, preferably the one with fewer letters.

six 4-inch bolts, 50 five-foot intervals

1d In compound adjectives of which the first element is a number, do not spell out the number.

7-story building, 5-mile railway, 3-phase generator

1e Do not spell out numbers under 10 when followed by an authorized abbreviation, except when the numerical statement is vague in nature; nor when the numbers follow such abbreviations as *vol.*, *fig.*, *no.*, etc, the numbers being used in an enumeration.

2 ft, 6 oz, 1 kg; *but* about six feet beyond; vol. 2, no. 4, fig. 1

1f When an approximation is intended, spell out all numbers.

1 This was a lively mining camp some twenty years ago.
2 We can give a hundred reasons for our preference.

1g Do not spell out numbers under 10 when followed by a decimal or common fraction.

1⅓, 2¾m, 6.5, 1.006

1h Use figures for all numbers in tables and charts.

2 Omit unnecessary ciphers in stating sums of money.

$3, *not* $3.00; $5000, *not* $5000.00

3 In decimal numbers having no units, place a cipher before the decimal point.

0.32 lb, *not* .32 lb; 0.039 in., *not* .039 in.

4 Use decimals in place of fractions whenever you mean to be exact.

1.25 ft, *but* a quarter-inch plate

5 Use figures for the day of the month when the month is given, for the time of day, and for ages of persons.

January 2, 2:30 p.m., 8 a.m., 52 years and 6 months

6a Decimals, degrees, dimensions, distances, enumerations,

money, percentages, weights, and like matter, should be expressed in figures.

> 3.1416, 45°, 3 cu ft, 6 miles, 24 pages, $0.89, 8%, 41 pounds, 90 bushels

6b But if the matter is not statistical, follow rule **1**.

> nine stamp mills, eight days; *but* The cement was tested at 4, 28, and 160 days.

7 Where there is a possibility of confusion in the use by itself of a number spelled out, add the figures enclosed in parentheses. This practice is seldom necessary except in legal documents.

> five (5); two thousand nine hundred eighty-five dollars and twenty-two cents ($2985.22)

8 Use commas in punctuating numbers of more than four digits.

> 50,000; *but* 5000

9 Arabic and Roman numerals are used when numbers are not written out, the Arabic numbers being most commonly used, the Roman numbers being reserved, for instance, for chapter headings, main headings of outlines, acts of plays, pages of a preface or introduction in a book. For examples of Arabic numerals (1, 2, 3, etc) and Roman numerals (I, II, III), see the outline of a technical article, p. 349 ff.

Uses of Capitalization

The commoner uses of capitalization are presented in the following paragraphs, which are arranged in alphabetical order.

1 Abbreviations of proper names

Capitalize abbreviations of proper names.

> St. Louis, Mo.; B. & S. gage.

Academic degrees. See §**10**.

Administrative bodies. See §**7**.

Buildings. See §**7**.

Cities. See §**4**.

Clubs. See §**6**.

Colleges. See §6.

Company names. See §3.

Corporation names. See §3.

Countries. See §4.

2 Days of the week, etc.

Capitalize the days of the week, months, holidays, historical periods and events. Do not capitalize the names of the seasons.

> Wednesday, April, Labor Day, Middle Ages, the World War, spring, autumn

Degrees. See §10.

Departments of government. See §7.

3 Firm names

Capitalize the names of business organizations.

> Blake & Hudson, Inc.; Albert Wrenn and Company

4a Geographic and political divisions

Capitalize the names of cities, states, countries, rivers, lakes, mountains, and other geographic and political terms. Capitalize the following common nouns when they are used as component parts of proper names and immediately follow or precede the word which they modify.

Alley
Aqueduct
Avenue
Bay
Branch (stream)
Canal
Canyon
Cape
Circle
County
Court
Creek
Desert
Falls
Fork (stream)
Fort
Gap
Gulch
Harbor
Head
Hill
Hills
Hollow
Island
Islands
Isle
Lake
Lane
Mount
Mountain
Mountains
Oasis
Ocean
Park
Pass
Place
Point
Range (mtn)
Ridge
River
Road
Run (stream)
Sea
Shoal
Sound
Spring
Square
Strait
Street
Tunnel
Valley

Chesapeake Bay, Bay of Fundy, Massachusetts and Delaware Bays, Bays of Fundy and Biscay, Delaware River and Bay, Hudson River, Mackenzie Pass, Cheyenne Canyon, Fulton Street, du Pont Circle, Mount Hood, Cape Horn

4b Capitalize the following terms when used as the synonyms for the names in parentheses:

Canal Zone (Panama)	Sound (Long Island Sound)
Delta (of the Mississippi River)	Peninsula (Spain)
Falls (Niagara)	Eastern Shore (of Maryland)
Gulf (of Mexico)	States (United States)
Isthmus (of Panama)	Capital (Washington)
Continent (Europe)	Coast (Pacific Coast)
Lakes (Great Lakes)	Canyon (Grand Canyon)

4c Names of geographic zones and sections of the world, when used as proper nouns, are capitalized.

the Arctic, the Tropics, the Levant, the Orient

4d Geographic terms used as common nouns, or to qualify nouns that specify merchandise, are not capitalized.

castile soap, chinese blue, delft, india rubber, prussian blue, german silver

4e Points of the compass are not capitalized except when they are used to particularize undefined geographical sections of a country.

1 I traveled west until I found the trail.
2 The South is attracting many new industries.
3 The Pacific Northwest is an empire of rich resources.

4f Capitalize all adjectives formed from geographic names.

Canadian, Mexican, Hawaiian, English, French

Government departments. See §7.

Headings. See §9.

Historical events and periods. See §2.

Holidays. See §2.

Judicial bodies. See §7.

5 Languages, races, and nationalities

Capitalize names of languages, races, and nationalities.

Spanish, Spaniard, Eskimo, French, Latin

Legislative bodies. See §7.

Names of persons. See §7.

Nationalities. See §5.

6 Organizations

Capitalize the names of clubs, societies, political parties, labor unions, and other organizations. Capitalize common nouns when they are used as component parts of these names.

Engineering Club, Socialist Party, Electricians Union

Political divisions. See §4.

Political parties. See §6.

7 Proper names

Capitalize all proper names when used as nouns or as adjectives: names of persons, names of buildings, administrative, judicial, and legislative bodies, departments of government, and so forth.

1 George Washington, Woolworth Building, Veterans Bureau, Supreme Court, League of Nations, State Department, Monroe Doctrine, the Armistice
2 The Senate will probably refuse to ratify the proposed treaty; *but* The amendment must be submitted to the legislatures of the several states. ("legislatures" and "states" are common nouns.)

Quotations. See §8.

Races. See §5.

Seasons. See §2.

Sections of country. See §4.

8 Sentences

The first word of a sentence begins with a capital. A direct quotation begins with a capital if it is a complete sentence. A fragment of a quotation or an indirect quotation does not begin with a capital.

1 "Your report is due at five o'clock," he said.
2 The watchman asked anxiously, "Have you seen anything out of the way?"
3 Professor Newton has stated, "It is doubtful if magnesia is ever combined in Portland cement."
4 Many specifications require that a certain percentage "shall pass a sieve having 2500 holes per square inch."

Societies. See §6.

States. See §4.

9 Titles of books, etc

Capitalize the first word and all subsequent important words in titles of books or articles, and headings of sections or chapters. Do not capitalize prepositions, conjunctions, and articles.

1 Construction of a Concrete Block Sewer in Toledo
2 The Solution of Flight with Rotative Wings
3 Elementary Theory of Elasticity in Amorphous Steel Bodies

10a Titles of courtesy, distinction, etc

Capitalize titles if used in connection with a person's name.

1 Metcalf and Eddy, Consulting Engineers
2 W. M. Brown, Engineer of Maintenance of Way

10b Capitalize the titles of the President and the Vice-President of the United States, the individual titles of the members of the President's Cabinet, and the title of the Chief Justice of the Supreme Court.

10c Capitalize titles used as synonyms for proper names.

1 You will go, Major, to New York.
2 I am anxious about the Chief.

CHAPTER 4

Correspondence

THE WRITING of letters constitutes the most important part of the writing of most engineers. They not only find it necessary to write letters of a general business nature—such as letters of inquiry, requests for information, order letters, letters of instruction—but they also use the letter form in which to write all but the most elaborate engineering reports.

The present chapter deals only with letters as such. Many of the principles of engineering correspondence are equally applicable to report writing, however, and should be kept in mind in the study of Chapter 5.[1]

The Form of the Letter

Since the letters of an engineer so frequently represent him and his work, it is of the utmost importance that his letters should do justice to him. A man is often judged by the sort of letter he writes. Is it accurate, assured, to the point? Or is it slipshod, uncertain, long-winded? The writer of a letter has it absolutely in his power to determine the impression he will make—good or bad. Consciously or unconsciously our judgment is swayed by little things. We distrust the professional man—surgeon, lawyer, engineer—whose errors in writing suggest that his education has been deficient. If he has slighted the fundamental subject of English, we have the uncomfortable feeling that he may have slighted the subjects in his special field.

The formal parts of business letters. The conventional formal parts of the ordinary business letter are: (1) the heading, (2) the inside address, (3) the salutation, (4) the "attention

[1] More specialized forms of letters are treated in Appendix C, "Correspondence, Orders, Reports of the Departments of War, Navy, and State," pp. 460 to 494.

of," (5) the subject, (6) the complimentary close and signature, and (7) the address on the envelope. The main features of these parts may for the sake of brevity be indicated in an outline form as follows:[2]

HEADING. On a letterhead, date centered two spaces below printed heading or at right side two to four spaces below printed heading.

On plain paper, address of writer and date, two inches or more below the top of the page, slightly to the right of center, ending with right margin of letter.

1

STONE AND WEBSTER ENGINEERING CORPORATION
49 Federal Street
Boston, Massachusetts

May 25, 1943

2

block - open punct

814 Hudson Terminal
30 Church Street
New York City
July 20, 1942

1417 South 15th Street
Philadelphia, Pa.
February 27, 1943

Indented

If a letter extends to more than one page, confusion is avoided if subsequent pages are briefly headed, or at least numbered, the number then appearing preferably in the upper right-hand corner.

N. Y. Edison Co., 2/27/43, page 2

[2] For specific details of the outline, the authors are indebted to Babenroth and Parkhurst, *Modern Business English*, third edition, Prentice-Hall, Inc., 1942.

INSIDE ADDRESS. Name, street number (if necessary), city, and state. First line always beginning at left margin, two to five spaces below heading; not more than four lines; name of state on same line with name of city.

The purpose of the inside address is to render the carbon copy of the letter intelligible and complete for the files.

SALUTATION. Dear Sir, Dear Madam, Dear Mr. or Mrs. or Miss ———, Gentlemen, etc, beginning at left margin of letter, two spaces below inside address.

Although a letter to a firm may be marked for the "attention of" an individual, the salutation is "Gentlemen" because the letter is actually addressed to the firm and may constitute a written agreement with the firm.

"ATTENTION OF." Halfway between inside address and salutation, starting flush with margin or indented two spaces or centered. (See Salutation.)

SUBJECT. With printed letterhead or plain sheet of paper, often centered two spaces below, or opposite, salutation. With printed letterhead, often a part of the printed material, at extreme left or extreme right. (See pp. 147, 155, 187, 196, 201.)

Burnham, Williams & Co.
818 Little Building
Boston, Mass.

Attention of Mr. J. M. Patterson

Gentlemen:

New York Edison Company
    55 Duane Street
        New York, N. Y.

Gentlemen:

            Subject: Turbo-Generator Test

Complimentary close and signature. "Very truly yours," "Yours truly," "Respectfully yours" (if addressed to a person of high office)—beginning middle of page, two spaces below last line of body. Signature two spaces below complimentary close. If name of writer is typed, space left between complimentary close and typed signature for longhand signature.

The complimentary close is limited, in formal correspondence, to variations of "Yours truly" and "Yours respectfully." The signature should always be handwritten; preferably also typed. If the name of the firm is used, the signature of the correspondent should be handwritten below it. The full, legal name of the firm should be used.

The initials of the person dictating a letter followed by the initials of the stenographer are sometimes placed in the lower left-hand corner for purposes of reference. If material is to be enclosed, "Encl." is added to remind the person who places the letter in the envelope.

also sincerely combinati

Respectfully yours,

Newark Sheet Metal Works, Inc.

W. I. Singer

By W. I. Singer
Sales Manager

WIS:ABM
Encl.

Yours very truly,

Howland R. James

Howland R. James

Chief Engineer

HRJ/M

ADDRESS ON ENVELOPE. Centered or slightly to right or left of center, not more than four lines, fifth line at lower left, double space between lines preferably, name of state preferably on a line by itself.[3]

Burnham, Williams & Co.
818 Little Building
Boston
Mass.

The Baton Construction Company, Inc.
1713 Sansom Street
Philadelphia
Pennsylvania

Attention Chief Engineer

Punctuation of the formal parts. There are two styles for punctuating the formal parts of the letter: open punctuation, which omits all marks of punctuation at the ends of lines, except when a line ends with an abbreviation; and close punctuation, which requires a mark of punctuation at the end of each line. Most writers who approve of the former style make an exception for the colon after the salutation and the comma after the complimentary close.[4]

[3] The United States Post Office prefers that the name of the state be written on a separate line. This usage is to be recommended also on the ground of good appearance. Putting the name of the state, often abbreviated, on the same line with the name of the city may be slightly more economical for the typist, but the advantage would hardly seem to justify the practice.

[4] Not a few business letters which come to us today omit all marks of punctuation at the ends of the lines of the formal parts. No marks appear after the salutation and after the complimentary close. The result is a most pleasing appearance. This sensible usage has, however, obtained up to the present only limited recognition among careful business-letter writers.

There is a growing preference for the use of open punctuation, which is in accord with the good general rule for all writing: "Use no more marks of punctuation than are necessary either for good appearance or for clearness."

General layout. The four principal forms for the layout of the business letter are

(1) the block,
(2) the indented,
(3) the combination block and indented, and
(4) the military.

Blocking means that each successive line of the formal parts and the text begins at the same point, the inside address and the text beginning at the left margin.

Indenting means that each successive line of the formal parts is set in to the right and that the first line of each paragraph of the body of the letter is set in several spaces from the left margin.

The combination block and indented form means that the formal parts are blocked and that each paragraph of the text is indented.

The military form means

(1) that the regular inside address and salutation and the complimentary close are omitted,
(2) that at the beginning appear the expressions

From:		Subject:
	or	
To:		To:
Subject:		

(3) that the paragraphs or divisions are usually numbered,
(4) that the text shows condensation, directness, and brevity of expression.

Illustrations of business letter forms. Various combinations of layout forms and punctuation styles are possible, as shown in the following illustrative letters.

BLOCK

FITCH, PARKER AND HARD, INC.
Electrical Engineers

ALAN FITCH
RALPH D. PARKER
C. MYRON HARD

524 SPALDING BUILDING
PORTLAND, OREGON

May 12, 1942

Messrs. Miller, Clark & Company
Seattle, Washington

Attention Mr. J. G. Miller

Estimate Sheet

Gentlemen:

We enclose a tentative estimate sheet covering the illuminating fixtures for your new building. The estimate has

. . . .

If this plan meets with your approval, we will at once prepare . . . .

Respectfully yours,

FITCH, PARKER AND HARD, INC.

T. R. Brown

T. R. Brown
Illumination Engineer

TRB/BKH
Encl.

FITCH, PARKER AND HARD, INC.
PORTLAND, OREGON

Messrs. Miller, Clark & Company

Seattle

Washington

Attention Mr. J. G. Miller

INDENTED, OPEN PUNCTUATION

1514 West Fifth Street
Wilmington, Delaware
March 13, 1943

The Hart and Jones Company
Philadelphia, Pennsylvania
Attention: Mr. George B. Doe
Gentlemen:

Subject: Delay in Shipment

The miscellaneous building materials which were ordered through George B. Doe. . . . .

Very truly yours,
William B. Jones
William B. Jones
Engineer in Charge

William B. Jones
1514 West Fifth Street
Wilmington, Delaware

The Hart and Jones Company
Philadelphia
Pennsylvania

Attention: Mr. George B. Doe

INDENTED, CLOSE PUNCTUATION

MILLER, CLARK & COMPANY
DRY GOODS

Office of the Manager *Seattle, Washington*
February 15, 1943.

Fitch, Parker and Hard, Inc.,
524 Spalding Building,
Portland, Oregon.

Attention of Mr. Ralph D. Parker.

Gentlemen:

Messrs. Varney & Blakely, Architects, who have designed our new 15-story building, have referred us to you for advice regarding the lighting to be installed.

If it will be convenient for you, we would suggest as the first step a conference at the architects' office in the Mohawk Building, Seattle.

If you will arrange an appointment with Mr. Varney and will let us know the time agreed upon, we shall make an effort to hold the date open.

Yours very truly,

MILLER, CLARK & COMPANY.

J. G. Miller

JGM/BR J. G. Miller, Manager.

MILLER, CLARK & COMPANY,
SEATTLE, WASHINGTON.

Fitch, Parker and Hard, Inc.,
524 Spalding Building,
Portland,
Oregon.

Attention Mr. Ralph D. Parker.

COMBINATION BLOCK AND INDENTED

1000 North Sixteenth Street
Philadelphia, Pennsylvania
June 26, 1942

The Westinghouse Electric and Manufacturing Co.
East Pittsburgh, Pennsylvania

Attention: Mr. Harry Doer

Gentlemen:

Subject: Air-circuit Breakers—our order of June 1

The Type D A breakers which were ordered on June 1 have already been installed. We are sending to you tentative plans. . . . .
. . . .

Very truly yours,

THE JONES AND JONES COMPANY

R. C. Jones

R. C. Jones, General Manager

RCJ/MM
Enclosures

The Jones and Jones Company
Philadelphia, Pa.

The Westinghouse Electric and Manufacturing Co.

East Pittsburgh

Pennsylvania

Attention: Mr. Harry Doer

MILITARY

SIMONS, CARTWRIGHT & CO.

Highway Engineers and Contractors

San Francisco, California

April 19, 1942

From: J. R. Simons, Chief Engineer

To: Frank B. Gray, Resident Engineer
Monrovia, California

Subject: Vista Highway—preliminary instructions

1 Our firm has been awarded the contract for the proposed scenic highway from Monrovia to the summit of Castle Mountain, a distance of 8.1 miles. You will be in immediate charge of all survey and construction work until the project is completed.

2 A copy of the contract specifications is enclosed, for your examination and guidance. Maps and blueprints are being sent under separate cover.

3 We desire first a preliminary inspection of the general route, with special reference as to whether the road can more economically be located to the east or the west of Cedar Hill. We have our choice of locations. Your recommendations will govern the location.

4 After this general examination, you will organize a survey party of about four men and begin the preliminary survey, working out from the Monrovia end. Note that the new road will coincide with Gibson Lane and portions of other country roads near Monrovia. This survey should be completed by May 15, at which time we shall send our inspector, Mr. Adams, to examine and approve the final location.

5 Expense and pay vouchers will be submitted bi-weekly, as heretofore.

J. R. Simons

Encl.

Essentials of a Good Letter

A well-written engineering letter, like any other good business letter, is characterized by the following essentials:

1 Correctness
2 Clearness
3 Conciseness
4 Completeness
5 Accuracy
6 Courtesy
7 Character

Correctness of form. Correctness in letter writing means the observance of accepted form. Although, as we have just seen, there is no one unvarying style of make-up, there are certain conventions which are common to all styles. Departures from these conventions may appear freakish and may result only in attracting attention to the form instead of to the content of the letter. Correctness is desirable partly for convenience, partly for courtesy. Good appearance makes both an immediate and a lasting impression. Contributing to a good appearance are the quality of the stationery, the taste shown in the printed letterhead, the position of the letter on the page, and the neatness of the typewriting.

Proper stationery is usually white, unruled paper of good quality, 8½ by 11 inches in size, with envelope to fit the paper. Cheaper grades of paper are often used for interdepartmental correspondence, and papers of different colors are sometimes used for "signal" purposes or for purposes of record. Sheets of smaller size than 8½ by 11 are sometimes used for sales letters or for interdepartmental memoranda.

The letterhead is usually printed. Good taste requires that it shall be simple and clear. The full legal name of the firm and its address are given. To these are sometimes added the names of officials, telephone number, cable address, and a list of branch offices. In the last instance, the branch office at which the letter is written may be printed in red. In correspondence from the field the engineer must often use unprinted stationery, and therefore he makes his own heading.

All letters should be typewritten, preferably in black ink. Most firms have an invariable rule that a carbon copy shall be retained and filed for every letter written. Without such a

carbon copy on file it is sometimes difficult to understand the reply.

The sheet is folded crosswise into thirds to fit the long envelope ($4\frac{1}{4}$ by $9\frac{1}{2}$); crosswise into halves and then into thirds to fit the conventional envelope ($3\frac{5}{8}$ by $6\frac{1}{2}$).

The body of the letter should be centered on the page, the relative position depending on the length of the letter and on the space occupied by the letterhead. Approximate sizes of margins are as follows: 1½ inches at the left, 1 inch at the right, and 1 inch at the bottom, and, for pages subsequent to the first, 1½ inches at the top.

Single or double spacing between the lines of the letter may be used, the decision again depending on the length of the letter. Double spacing is generally used between paragraphs. Triple spacing sometimes makes for greater emphasis of the separate paragraphs.

For the numbering of pages, see the discussion of headings on page 146.

Clearness of development. A good letter should be immediately understandable. The recipient of a letter must get its meaning with minimum effort. The writer must therefore so combine his words that they make good sense. In other words, clear writing is largely a matter of clear thinking. Muddled writing is generally a sign of muddled thinking; less frequently, though frequently enough, it is a sign of careless composition, of neglect of the writer to make sure that what he has said means exactly what he intends it to mean. A writer should remember that an expression which stands for a perfectly clear idea in his mind may be entirely obscure to even an intelligent reader.

Think before you write. (1) Think your material over in order to determine its limits; thus you will be prepared to concentrate on a single purpose in each letter. To facilitate filing, some offices require the writing of a separate letter for each subject. Certainly no one letter ought to contain utterly unrelated subjects. (2) Think your subject through in order to see the relation of all its parts to one another and to the whole; thus you will be able to build an orderly letter, with each part falling into a logical progression of ideas. (3) Think over the attitude of your reader, in order to arrange the parts of the letter for immediate comprehension and effective emphasis.

Even experienced letter writers profit from the making of an informal or a formal outline for letters of more than three or four paragraphs. Particularly necessary is the outlining of a letter report, which often runs to several pages in length. Careful outlining in mind or on paper facilitates dictation and also helps to effect a logical development in the dictated letter. Proper arrangement makes for emphasis as well as for clearness.

The first and the last sentences are the most emphatic points in the letter. Use the first sentence to tell your reader what you are driving at and, if necessary, to win his attention. Use the last sentence for some highly specific statement, such as urging your reader to action. Don't waste the last sentence on a meaningless participial construction, such as "Thanking you for your inquiry and hoping that we may have the opportunity of serving you, we are . . . ." Use instead a direct, concise, conclusive statement.

In paragraphing letters, the writer must keep in mind the distinction between paragraphs of related statements and paragraphs of isolated statement. For a full discussion of this subject see page 34. Many statements in business letters require single-sentence paragraphs or divisions. The revision of the following poorly paragraphed letter illustrates the gain in clearness which comes from proper paragraphing.

ORIGINAL

In answer to your letter of January 27, we recommend for your class of work the Acme Automatic Engine, complete as per catalog, including foundation-bolts and wood templet.

The 9 by 10 engine will develop 35 hp at 275 rpm and 100 lb isp.

The price of this engine will be $400, or, if you wish a slower speed engine, we can furnish a 10 by 12 model which will develop 40 hp at 240 rpm and 80 lb isp.

The price of this engine is $550. The foregoing prices are f.o.b. cars Ontario, N. Y., with freight allowed to Newark, Mary-

REVISION

In answer to your letter of January 27, we recommend for your class of work the Acme Automatic Engine.

The 9 by 10 engine will develop 35 hp at 275 rpm and 100 lb isp. The price of this engine complete according to catalog, including foundation-bolts and wood templet, is $400.

If you wish a slower speed engine, we can furnish a 10 by 12 model. This engine will develop 40 hp at 240 rpm and 80 lb isp. The price of this engine is $550.

The foregoing prices are f.o.b. cars Ontario, N. Y., with freight allowed to Newark, Maryland.

land. We can ship either of these engines within five or six days after receipt of order, as both models are in stock.

We enclose a copy of the list of installations which we are making at the present time.

We can ship either of these engines within five or six days after receipt of order, as both models are in stock.

We enclose a copy of the list of installations which we are making at the present time.

Clearness is impaired by the use of inaccurate, vague, ambiguous, and hackneyed words or phrases. The following expressions are especially to be avoided in correspondence:

Above, as an adjective. Say "above-mentioned, foregoing, preceding."
Advise. Often misused for "notify, inform, tell."
Along this line. Say "in this subject, department, field, division," etc.
Awaiting your further favors. Better: "We shall be pleased to receive further orders from you."
And oblige. Omit.
As per. Say "according to."
At hand. Say "received."
Beg to say, beg to state. Say "wish to say, wish to state," or omit.
By even mail. Omit, or refer to date.
Inst, prox, ult. Use month and day, as "your letter of February 25."
Our Mr. Blank. Say, for instance, "Mr. Blank, our representative."
Recent date. Always use specific date, as, "your letter of June 12."
Re, except in headings. Not to be used for "about" or "concerning."
Same, as pronoun. Wrong: "We have sent you a complete statement and hope that you will receive same [it] promptly."
Thanking you in advance. Avoid this hackneyed expression.
Trust or *trusting.* Often misused for *hope* or *hoping.*
Valued favor. Say "letter."
We hand you herewith. Better: "We enclose."
Your esteemed favor. Say "your letter."

Conciseness of expression. Technical and business executives know that both the dictation and the reading of letters cost money. Letters should be concise. Diffuseness will spoil the effect of an otherwise creditable letter. The inexperienced writer will find that it pays to go over his letters carefully, condensing and improving his expression wherever possible. Especially if he is new at giving dictation, he will have to learn the vast difference between speech and writing and will have to cultivate

in his dictation the tighter, more economical style of written language. Strong and effective writing depends, to a considerable degree, upon knowing what to leave out. Notice, for example, with what needless frequency "very" appears in an unskillful letter.

Brevity must not be obtained, however, at the expense of grammatical or logical completeness. The personal pronouns "I" and "we," or an essential verb, or the noun after the possessive case, should not be omitted. Nor must brevity be obtained at the expense of completeness of information, however long the letter may become. Finally, clearness must not be sacrificed to brevity. Take all the words you need to make your meaning plainly intelligible. Good judgment must be your guide. Be as brief as is consistent with accuracy, completeness, and clearness.

Notice the saving of words effected in the revision of the following letter:

ORIGINAL

Referring to previous correspondence in regard to iron pipe, I noticed in the newspaper a statement to the effect that it was your intention to proceed with the sewer work, and in the event of the report being true, I would be very glad to have you advise whether you are ready to take up the subject of purchasing iron pipe. If so, I shall be pleased to call upon you any day next week that may prove suitable to your convenience.

In this connection, I beg to advise that I will be very pleased to furnish you price for twisted steel concrete bars, provided you contemplate using them in your sewer work. Mr. J. F. Costigan has thoroughly tested the Mowry Special bar which I sell, and I feel certain that he will be glad to give you the results of his tests if you will apply to him.

Trusting to have the pleasure of seeing you in the near future,
I remain,

REVISION

From a recent newspaper statement I infer that you intend to proceed with the sewer work concerning which we have had previous correspondence. If you are ready to take up the subject of purchasing iron pipe, I shall be glad to call upon you any day next week that may suit your convenience.

In this connection, I should be pleased to furnish you a price for twisted steel concrete bars if you contemplate using them in your sewer work. Mr. J. F. Costigan has thoroughly tested the Mowry Special bar which I sell, and I am certain that he will be glad to give you his results.

The following list[5] illustrates the gain which comes from economy in the use of words:

LONG FORM	SHORTER FORM
Purchasing Agent	Buyer
the purchase of	buying
a large number of	many
a majority of	most
the sum of $10,000	$10,000
take into consideration	consider
the city of Boston	Boston
this has been found to be an encouragement to good work	this encourages good work
extend our invitation	invite
enough so that it will do	enough to do
due to the fact that	because
over and above	over (or more than)
in a prudent manner	prudently
put in an appearance	appear
it is often the case that men fail to	men often fail to
enclosed herewith please find	I enclose
beg to acknowledge	acknowledge
beg to advise	notify
beg leave to inform	inform

Completeness of information. An adequate knowledge of the subject matter is essential for the composition of a good letter. However important conciseness of style may be, there must be no skimping of matter necessary to an intelligent understanding of the message. Frequently there must be some thought of adapting the letter to the limitations of the reader's knowledge. If, for example, one is writing a letter of instruction to a subordinate, it may be necessary to go into considerable detail in order to make the instructions explicit. On the other hand, a memorandum between two engineers familiar with a job can afford to take a good deal of common knowledge for granted.

If a letter of inquiry is received to which it is not immediately possible to make a complete and definite reply, nothing but a brief acknowledgment should be written. No purpose is served by a vague and rambling letter concluding with a promise of a real letter later.

Letters are written for purposes of record as well as for information. Hence they should be sufficiently complete to be

[5] Adapted from *System*, August, 1914

self-explanatory at any future date, or should contain such references to other correspondence as will make their meaning complete. In order to standardize procedure, many firms insist that all matters be handled by impersonal correspondence.

Besides seeing that the body of the letter is complete, one must be sure that the information required in the formal parts of the letter is complete. If the earlier suggestions for correct form have been followed, the letter will contain answers to the following questions: when and where was it written? to whom and at what address? attention of what individual? in reply to a letter of what date? who wrote or dictated it? what was his official position? who typed it?

Telegrams are necessarily shorter than letters, but there is no economy in making a telegram so brief that it is unintelligible or lacking in necessary information. The use of long and expensive telegrams may sometimes be forestalled by anticipating your correspondents' needs for information.

Finally, the letter writer must be warned against allowing his zeal for completeness to tempt him to include the irrelevant.

Accuracy of details. The first impression made by a letter depends largely on accuracy in such small details of expression as spelling, grammar, punctuation, abbreviation, and hyphenation. Freedom from errors in these details is as necessary in a letter as are good manners in social intercourse. The world, fairly or unfairly, bases its judgment of a man on what may appear to be trifles. Hence, a writer who allows inaccuracies of form to slip into his letters will be held capable of inaccuracies of fact in his handling of technical data. Such a conclusion may be unjust, but it is inevitable.

Misspelled words and bad grammar do not, as a rule, tend to obscure the sense of a letter, but they do seriously impair its effectiveness. Faulty punctuation often confuses the meaning and causes the reader greater effort to understand exactly what the writer intended to say. In technical instructions, mispunctuation may even cause such a misinterpretation of meaning as to result in financial loss or even graver consequences. Shortened forms of sentences, in which, for purposes of condensation, important parts of speech are omitted, may be allowed in tabulated statements, enumerations, headings, or other directive expressions. In the text, complete sentences are always safer than incomplete ones.

Accuracy of substance concerns the writer of engineering correspondence even more than accuracy of form: he must be precise in his technical data. Dimensions, distances, speeds, prices, ratings, and similar details must be scrupulously checked. It is not enough to sign a letter after the stenographer has typed it; the facts must be verified by the person who dictated the letter.

Courtesy deeper than form. Courtesy in a business letter is, in its simplest sense, nothing more than an observance of accepted forms. The salutation and the complimentary close are simply the greeting and the adieu of polite intercourse. In the opening sentence it is often desirable to express thanks for the letter to which you are replying. Courteous phrasing throughout the body of the letter and especially at the close is expected of every gentleman. So long as the attention paid to the forms of courtesy remains within the bounds of good taste and sincerity, it may, even with matter-of-fact businessmen and in an affair which involves only the coldest calculation, help considerably in overcoming the objections of a man whose good will is needed.

But courtesy in the business letter goes much deeper than the surface. Courtesy, in its truer sense, is the effort which the writer of a letter makes to see things from the point of view of the recipient. Every letter then becomes a special problem. It takes a special appeal, either direct or indirect, to a particular person. *I, we, our* give way to *you, your.* Especially in letters of application, sales letters, and other letters involving an effort at persuasion or conviction, the "you attitude" must pervade every line. A prospective employer is interested in what you will bring *to* him, not in what you may hope to get *from* him. A prospective customer is interested in those features of your product that will benefit him; he is not at all interested in other features which, from your point of view, make it a salable and profitable product.

Much engineering correspondence is, of course, of a routine nature or deals with material which allows small opportunity for displaying the amenities. But it is the rare letter which is not a little better if its writer has learned to put himself instinctively in the place of his reader, and to adapt his ideas and his expression to fit the preferences, limitations, even the prejudices, of the man with whom he would do business.

In the following example the "you attitude" underlies courtesy of form:

> We acknowledge with thanks your inquiry of March 28 and take pleasure in sending you a copy of our catalog. You will find on page 34, second column, a list of the collets with which our Marvin Wire Feed Turret Lathe No. 86 (1-in. capacity) is equipped.
>
> We hope that this information will serve to answer fully your inquiry and that we may be favored with a visit of inspection from your representative.

The following contrasting specimens of sales-department letters illustrate admirably the importance of courtesy.

ORIGINAL	REVISION
1[6]	
We have your letter of May 1 asking us for permission to return . . . which you ordered by mistake. You may return the . . ., transportation charges prepaid, and upon receipt of the shipment we will send you a credit.	This morning we received your letter of May 1. It will be a real pleasure, Mr. Jones, to relieve you of the . . . which you inadvertently ordered in excess of your present needs. Just ship the merchandise right back to us, transportation charges paid, and promptly upon receipt of it we'll send you a credit.
2	
We have your order No. 236 of April 6 for one copy of the <u>Technical Manual</u>, edited by R. A. Teal. However, we have no way of knowing which book you want. There is a whole series and you have not specified which book you have in mind. The <u>Technical Manual</u> Series was started in 1932 and continued up to and including the 1942 edition, although the earlier editions are now out of print. Will you advise us whether it is the last one you want and we will send it to you promptly. Again thanking you for your order and trusting you find the <u>Manual</u> helpful, we are,	Thank you for your order No. 236 for one copy of the <u>Technical Manual</u>, edited by R. A. Teal. Before we can be sure that we are sending you the book you want, however, we must explain that the <u>Manual</u> is a series. The last book in the series was published in 1942. We are wondering whether this is the book you have in mind. The series was started in 1932, but the earlier editions are now out of print. We'll be glad to send you one copy of any book in this series from 1938 to 1942 just as soon as we receive your reply. Thanks again for your interest in our publication.

[6] Reprinted from "Letters That 'Go to Town,'" by Charles A. Emley, Sales Promotion Manager, DeLong Hook and Eye Company, *American Business*, July, 1941

Character: a summary. Character in a letter is the summary of all the qualities already enumerated. If a letter is correct, clear, concise, complete, accurate, courteous, and original, it has character. In other words, it reflects a personality at once dependable, logically minded, direct, alert, gentlemanly. How do we know all this about the writer? We know it just as we deduce a man's character from his clothes, his manner, or his speech. No single thing tells the whole story, but the whole story is implicit in the aggregate of details.

Character—real character—is something that cannot be injected into a letter to order. It is easy enough to overlay a letter with a veneer that tries to pass for character—informality or pompousness or effusive friendliness—but real character springs spontaneously from habits of thought and action bred into a writer by his experience and his human contacts. It must be cultivated in his living if it is to be apparent in his writing. When a man writes a letter, he puts himself on paper.

Types of Engineering Letters

The following specimens illustrate the commoner types of letters which an engineer may be called upon to write. Actual experience in correspondence, however, will furnish many situations which cannot be handled by any mere model. These examples are suggestive only.

1 Application
2 Invitation
3 Request for information or advice
4 Instructions
5 Transmittal
6 Authorization
7 Interdepartmental memoranda
8 Sales
9 Inquiry
10 Quotation
11 Order
12 Claim
13 Follow-up
14 Series

Letter of application. A complete letter of application covers the following points, the selection of details and method of paragraphing depending on the particular circumstances of each letter:

1 *The application proper.* Make application for a definite position and state your source of information or special reason for application.

2 *Education.* Give in detail only such information as you think will be of interest to the prospective employer.

3 *Experience.* Record completely, with dates and names of employers, the positions you have held. Leave no unexplained gaps. Usually this material is tabulated.

4 *Qualifications.* Discuss your qualifications, emphasizing only such details as prove your special fitness for the position.

5 *Salary.* Refer to salary. The importance of this point varies with the age, experience, standing, and immediate aim of the applicant.

6 *Personal data.*

7 *References.* Give full names, titles, and addresses.

8 *Final appeal.* In the closing paragraph, emphasize the main point in your qualifications, or suggest an interview, or politely urge early and definite action.

The use of these details of content and the order in which they ought to appear vary of course with each letter of application. The application proper might lead directly, in the second paragraph, to a brief specific statement of qualifications (item No. 4). A prospective graduate engineer who has had little practical experience might combine No. 2 and No. 3 and possibly No. 4 in a single paragraph. He might omit altogether the reference to salary. "Personal data" in a letter which includes all information between the salutation and the complimentary close might well come before or after references; in a brief letter to which a complete "record" is attached, such information might appear as the first item on the attached sheet. It is often very difficult to present a good closing paragraph. If nothing suggests itself as a "clincher," the letter may well close: with the mere mention of the method of communication with the applicant, with an expression of his readiness to appear for an interview or to furnish additional information, with a suggestion of his hope that he may have a chance to show what he can do, or with a statement about his confidence that he is adequately equipped for the contemplated position.

Certain specific suggestions will be found helpful in the writing of a successful letter of application:

1 Strive especially for correctness of form. The applicant who understands the importance of first impressions will not only polish his shoes and wear a clean collar when he goes to an interview, but he will also first see that his letter of ap-

plication presents an attractive appearance. Use plain white paper. It is poor policy to use the letterhead of a hotel, club, fraternity, or the firm that you are working for, as it is sailing under false colors and suggests that you cannot stand on your own merits. Type your letter, neatly and accurately. If you don't know how to type, employ a public stenographer. Spell and punctuate correctly. Copy proper names and titles exactly. Follow established usage in the formal parts, and arrange your matter effectively on the page.

2 Try to make your first sentence so effective that the whole letter will be read. See to it that your first paragraph indicates definitely what you wish to obtain. The following beginnings are in marked contrast:

ORIGINAL	REVISION
I have noticed your name in the "Eng. News" and am taking the liberty to ask this favor of you. I am attending college but have to leave, so am looking for work.	Graduating next March from the University of Toledo with the degree of Bachelor of Electrical Engineering, I should very much like to continue my association with the Branon Powder Company. I served during the summer of 1941 as a tracer in Mr. John Baker's department and during the summer of 1942 as a member of the Electrical Squad under the direction of Mr. Harvey Williams. I am very much interested in the work of the electrical division.

3 Make the letter expressive of your personality. (But don't strain so hard for effect that your letter merely seems cute or smart.) Try to attract and hold the attention of the reader in ways that are natural to you. A purely conventional, colorless letter of application may be thrown into the wastebasket; a letter with an individual touch may bring results at once or may find a place in a file of letters for future consideration. If your letter can in some way give to a prospective employer an impression of your intelligence, your reliability, your serious purpose, you will have accomplished much toward a favorable reply.

A consulting civil engineer says: "There is a feeling among most people that a letter of application for a position does little good, as it is usually placed on file for future reference. Very

often it is the fault of the letter itself. Personally I believe thoroughly in letters of application, and almost invariably exact one from each applicant. If the spelling is correct and the wording good, it is a fair indication that the man will be painstaking in his work as well as in his letter writing. There is every opportunity to show originality in letters, and the man who can catch the attention of a busy executive engineer or a businessman by a letter of application is likely to have that letter answered immediately. At any rate his communication will be left in a conspicuous place for ready reference."

4 Be modest but not self-deprecatory. Be fair to yourself. Nobody is going to value you higher than you value yourself. The first of the following examples is over-modest; in the second, every sentence begins with the pronoun "I."

1

Have you a position open for a young man in your line of work? If so, the writer respectfully offers himself as a candidate for that position. He will graduate shortly from the Hargraves Technical Institute after having completed a course in Civil and Sanitary Engineering. Further particulars will be furnished upon request.

Thanking you for any favors that I may receive from you,
I am,

2

I am a graduate of Smith University. I have had two years' experience in telephone construction with the New England Telephone & Telegraph Co. I resigned from this position last year to join the faculty of the Claremont School of Technology as a teacher of Electrical Engineering. I would prefer to go back to active engineering practice.

I am especially experienced in engineering superintendence of construction work, keeping of engineering records and cost data, making of estimates, etc. I have transit and transit equipment. I shall soon be free. I would consider an engagement of permanent nature, or an engagement to last from June 1 to about October 1.

5 If a letter of application is unsuccessful, it is good policy to follow up the rejection by a courteous reminder that you hope to be considered for a subsequent appointment. Such a letter as the following may serve to keep your application alive until a new opening occurs.

I regret very much to learn that the position of research chemist in your laboratories for which I applied on May 18 has been filled. I hope that you will keep me in mind if another vacancy should occur

in the near future. The opportunities for individual work which such a position offers appeal to me strongly. I shall take the liberty of renewing my application before the end of the summer.

The four letters which follow, three letters of application and one follow-up letter, illustrate ways in which many details may be worked into smooth paragraphs.

1

2118 Gilles Street
Wilmington, Delaware
October 22, 1941

The Lukens Steel Company
Coatesville
Pennsylvania

Gentlemen:

The association with your firm during my school vacation last summer was a most beneficial and enjoyable experience. I should like to continue working with your organization after my graduation from college next June, and I hereby submit my application for a position.

I expect to be graduated from the University of Delaware on June 8, 1942, with the degree of Bachelor of Mechanical Engineering. My course has been characterized by extensive study of heat-power engineering and of the strength of materials. The application which I filed with you last summer will furnish you with details of my education prior to entering college.

During the months of June to September, inclusive, last summer, I was temporarily employed by the By-Products Division of your firm. My work as a mechanic's helper, although not of a technical nature, did enable me to study general plant operation and significant manufacturing processes.

I should like to work in some branch of industrial engineering and have a definite preference for industrial-relations work or sales work. The experience which I have gained from continually meeting and dealing with all classes of people in the past should be of much assistance in work of this nature.

I am twenty-three years of age, of American nationality, single, and in good health.

Lukens Steel Co., 10/22/41, page 2

As to my character and general fitness, I have permission to use the following additional references:

Dean Robert L. Spencer
College of Engineering
University of Delaware
Newark, Delaware

Mr. Walter J. Beadle, Assistant Director
Development Department
E. I. duPont de Nemours & Company, Inc.
Wilmington, Delaware

Mr. Thomas N. Stapleton, Legal Investigator
Legal Department
E. I. duPont de Nemours & Company, Inc.
Wilmington, Delaware

If my application should receive favorable consideration, I should be much pleased to submit any further information that you may desire.

Yours very truly,

H. W. Ivan

2

651 Rockford Street
Barstow, Illinois
March 12, 1938

Messrs. Amidon, Kent & Company
812 Merrick Building
Atlanta, Georgia

Gentlemen:

Believing that a young man with my industrial engineering experience in the textile industry could be of worth to your company, I am writing to apply for a position.

I was graduated from the Kenosha University Mechanical Engineering course in June, 1930, and have since been employed by the leading hosiery manufacturer of this city. My experience has included time study and the computation of standard operation times; the departmental layout of machine shop and hosiery machinery; and shop work in a steel mill prior to my graduation and in the factory where I am at present employed. I have gained a knowledge of cost accounting and production control from study and from contact with these departments of factory operation.

The time study and standard computation have been done in connection with a premium wage payment system, which also requires the analysis of individual and group production records and indirect labor costs. I am at present responsible for time study, standard computation, and labor production analysis in the factory of my employer.

I should like to continue working in some branch of industrial engineering, and have a preference for the textile industry. I am not married, and it is immaterial whether my work requires traveling or permanent location at one factory.

Although the question of salary is not of the greatest importance at this moment, I should not care to consider a salary of less than $3000.

I have permission to use the following references:

Professor John L. Sweet
College of Engineering
Kenosha University
Kenosha, Wisconsin

Mr. L. W. Woburn, Cashier
Calvin National Bank
Calvin, Nebraska

Mr. E. P. Berman
239 Highland Avenue
St. Louis, Missouri

Mr. Berman was formerly an industrial engineer in this city, and was my superior for more than a year.

I shall be ready of course to give you any further information you require, and could call at your Chicago office, preferably on a Saturday, should you so desire.

Respectfully yours,

George Bradford

3

823 Winthrop Avenue
Portland, Maine
May 15, 1942

The Peabody Engineering Corporation
1211 Petersham Building
Boston, Massachusetts

Gentlemen:

If you think that you could use in your organization a man with the qualifications which are suggested by the enclosed detailed statement of my experience, I should be pleased to give you further information or to come to Boston for an interview.

The attached record gives an outline of my experience. My fifteen years of varied technical and executive training afford an unusual background of knowledge applicable to almost any industry. I have, in addition, initiative, energy, and enthusiasm, and a happy faculty for getting along with my associates.

Can you use me as a production executive or in personnel work?

Yours very truly,

Enclosure

S. B. Joseph

Record of S. B. Joseph
823 Winthrop Ave., Portland, Maine

American descent	Height—5 ft 10 in.
Married; 3 dependents	Weight—165 pounds
Age—40	Health—Excellent

EDUCATION	Colorado School of Mines, Golden, Colo. Graduated 1927 with degrees of B.S. and M.E.
EXPERIENCE[7]	
Nov. 1940 to date	Western Electric Co., Elmwood Works, Evanston, Ill.

[7] Observe that this experience list goes backward in time.

	Alteration of a group of buildings and installation of plant for the manufacture of telephone switchboards.
	Organization and direction of service department of 75 people.
Sept. 1937 to Oct. 1940	National Copper Company, Acequia, Chile, S. A.
	Maintenance of extensive accessory plants and supervision of the entire economic life of six isolated communities.
	Creation and organization of new department of safety engineering.
	Detailed acquaintance with every feature of this large property and intimate contact with all having any degree of authority.
Feb. 1928 to June 1937	New York Zinc Co., Kingston, N. Y.
	Large-scale experiments in ore dressing and the magnetic separation of a variety of materials; plant maintenance; production records.
	Maintenance of company railway.
	Direct charge of one division of property; preparation of operating reports.

REFERENCES

Mr. Harold A. Giblin, Works Manager
Western Electric Company
Brigham Avenue
Evanston, Illinois

Mr. Hugh Poole, Vice-President
National Copper Company
120 Broadway
New York City

Mr. S. R. Stolze, Superintendent
New York Zinc Co.
Kingston, N. Y.

4

LaFayette, Indiana
December 14, 1941

Director of Research
Eastman Kodak Company
Rochester, New York

Dear Sir:

In response to your request for further information about my ability to fulfill the requirements of the vacant position in your laboratories, I am pleased to submit the following.

1 The Chemical Engineering course at Purdue University has given me a thorough preparation in general chemistry and a rigorous treatment of the Unit Operations of particular interest to the Chemical Engineer. My curriculum also included enough basic Mechanical and Electrical Engineering to enable me to solve many problems in these divisions without recourse to specialized help.

2 Many of my courses in the last two years have included preparations necessary for research in the field of photochemistry. Organic Chemistry and Organic Chemistry Laboratory have been instrumental in interesting me in the synthesis of organic oxidizing and reducing agents which are useful or potentially useful to the chemistry of photography. Physical Chemistry Laboratory has served to further my study of photochemistry. Unit Operations and Unit Operations Laboratory have given me fundamental and specific knowledge of the problems of industrial production and purification of chemicals, organic and inorganic.

3 For many years I have been interested in the mechanical and chemical processes of photography. I have had a laboratory-dark-room in my cellar for the past six years. I have studied and experimented with most of the photographic materials and processes which are in general use. At present, I am trying to compound a new film developer of the para-phenylene-diamine type which will give the contrast generally afforded only by hydroquinone, but which will have the small grain size inherent in para-phenylene-diamine developers.

I hope that the foregoing statement may justify your giving me further consideration.

Very truly yours,

James F. Conard

Letter of invitation. Engineering students may sometimes have occasion to invite an eminent technical man to speak before an undergraduate engineering society. The courtesy of the writer should be expressed in his tone and in his anxiety to make proper arrangements for the convenience of the speaker.

University of Delaware
Newark, Delaware
November 5, 1942

Dr. W. H. Reinhardt
E. I. duPont de Nemours & Company, Inc.
Wilmington, Delaware

Dear Sir:

The University of Delaware Student Chapter of the American Institute of Chemical Engineers requests the pleasure of your presence as guest of honor at its annual banquet to be held on Friday evening, November 20, 1942, at six o'clock in Old College of the University of Delaware.

We should be greatly pleased if you would tell us of your experiences as Director of Personnel of E. I. duPont de Nemours & Company. As future chemical engineers, we are all keenly interested in knowing the qualifications that we are expected to meet as well as the type of work we may expect after graduating from college. With world conditions as they are today, we believe that it is of the utmost importance that engineering students have a thorough knowledge of their role in the construction of a better world.

The University of Delaware Student Chapter of the American Institute of Chemical Engineers has eighty members, all of whom are planning to attend the banquet. In addition to these men, there will be present the presidents of the University of Delaware Student Chapters of the American Society of Civil Engineers, the American Society of Electrical Engineers, and the American Society of Mechanical Engineers as well as Dr. A. P. Colburn, Professor of Chemical Engineering.

If you can conveniently be with us at this time, will you kindly let us know shortly in order that we may make final arrangements for the banquet?

Very truly yours,

Thomas B. Evans
Secretary

Request for information or advice. In a letter requesting information or advice, clearness and completeness are all-important. The exact nature of the problem must be clearly stated and all facts relative to it must be explained.

State College, Pa.
November 4, 1941

Mr. Sterling Lester, Instructor
School of Engineering
Pennsylvania State College

Dear Mr. Lester:

I have recently worked out the calculations and design data for the test leading to the desired results in the "Design of a Starting Rheostat." As you no doubt recall, on Wednesday, October 29, you gave me advice and assistance in the preliminary calculations. Unfortunately, I seem to have become confused on a few minor points, and I should like to ask your advice.

Using as a reference the chapter in Ricker and Tucker dealing with such a design, I found, by use of construction and calculation, that the total resistance needed in the rheostat was 7.62 ohms. The construction led to the conclusion that five steps were needed.

The next step, of course, was to find the proper size and length of wire to give the necessary resistance. The wire had to have sufficient area to dissipate the power through the wire at a wattage density of not more than five watts per square inch. Therefore, starting with this hypothesis, and working by trial and error, I found that 81.66 feet of No. 12 wire would properly dissipate the heat and at the same time provide a total resistance of 7.75 ohms. This, you see, is a little more than is needed to satisfy Ohm's law. If this much wire is used, the resistances for each step are too little.

There seems, therefore, to be a choice in the matter of specifying a total resistance in the design data. Is it more important to satisfy Ohm's law by using 7.62 ohms, or should the watts density be kept at exactly five watts per square inch by using 7.75 ohms?

My opinion is that the wire could stand to dissipate more than five watts per square inch, as it would if the smaller resistance were used in the rheostat. However, I realize that

my experience in designing starting equipment is limited. Until you can tell me which total resistance to specify, I cannot submit the final design of the rheostat with resistances and lengths of wire for the other four steps.

Will you please send to me, through the College mail, the information that I need?

Very truly yours,

[R. D. M.]

Letter of instructions. The following directions apply to any set of instructions, whether presented in the form of a letter or otherwise.

1 Adjust your language to the intelligence of the person to whom the order or instructions are issued. Avoid all words or statements which will not be at once clear. Instructions must be so clear that they cannot be misunderstood or evaded. Do not take too much for granted. Put yourself in your reader's place.

2 Use the imperative mood for specific directions or instructions. Use the indicative mood for explanations, which often precede or follow directions.

3 Make perfectly clear when the person addressed may in part exercise his own judgment and when he must follow directions implicitly.

4 Be sure that the order in which you present your instructions is logical and that complete directions are given for the successive steps in the operation.

5 Write briefly, concisely, and to the point, avoiding all roundabout expressions, unnecessary or vague words, and generalities.

6 Employ paragraphs of isolated statement, unless an item needs to be explained or discussed, or several items are closely related.

7 Avoid as a rule incomplete sentences, involving omission of grammatical subject and predicate, of object of transitive verb, of definite or indefinite article.

8 Make use of such devices for clearness as numbering of

sections, underlining of important phrases, headings for main divisions, and drawings.

The specimens of written instructions which follow include (1) a typical letter of instructions, (2) a letter involving explanation, (3 and 4) field orders, and (5) a brief set of instructions not in letter form.[8]

1

207 North Connell Street
San Francisco, California
October 27, 1941

Mr. John A. Redding
University of Pennsylvania
Philadelphia, Pennsylvania

Dear Sir:

The following instructions for the making of reproductions of drawings and graphs by the use of Ozalid printing paper are being sent to you at the request of Dr. J. M. Baker.

Materials
Tracing cloth, tracing-type graph paper, lettering sets, ink, and Ozalid printing paper are kept in Dr. Baker's office for the use of the department.

Equipment
A vertical blue-printing machine and a developing cylinder for the Ozalid paper are set up in a room on the ground floor of Evans Hall.

Drawings
For good reproduction, all sketches and graphs must be drawn in India ink on tracing paper. Lettering may be free-hand or stenciled in India ink, or typewritten, a reversed sheet of carbon paper being used to give the necessary opacity.

Printing Paper
Ozalid paper is exposed in the usual manner in the blue-printing machine, and then is placed in a metal cylinder over a reservoir containing concentrated aqua ammonia. The action of the ammonia fumes develops

[8] For a specimen of "generalized instructions," including explanations and information, the reader is referred to "How to Select, Install, and Maintain Electric Motors," by O. F. Vea, *General Electric Review*, Vol. 45, No. 6 (June, 1942), pp. 335-342.

Mr. John A. Redding
10/27/41
Page 2

the image in about five minutes, and produces a permanent red-line print. If the background of the print has a reddish cast, the copy has been underexposed and the printing time should be increased. If the lines and letters are a faded pink, the print has been overexposed and the printing time should be decreased.

Procedure

1 Unwrap the Ozalid paper in the dark-room and cut the paper to size.

2 Place the original drawing face inward on the glass of the printing machine. Superimpose the sheet of printing paper with the yellow sensitized surface toward the light, and close the canvas cover of the machine.

3 Raise the carbon-arc lamp by means of the crank until the gap between the electrodes is just above the top of the drawing.

4 Set the pointer on the hydraulic piston to the proper exposure time, usually about the point 5, and light the lamp. Release the ratchet and allow the lamp to travel downward.

5 When the level of the arc has passed below the bottom of the print, shut off the light and open the canvas cover of the printing machine. Remove the print and place it in the ammonia cylinder for development.

Yours very truly,

[R. H. R.]

2

ATCHISON CONSTRUCTION COMPANY
Eugene, Oregon

April 23, 1942

Mr. R. J. Benson, Constr. Foreman
Crystal Creek, Oregon

Dear Sir:

Our inspector, Mr. Wallace, after conferring with a number of farmers in the Crystal Creek district and examining the north canal, has suggested a few changes which should be made before water is turned in.

Beginning Friday, April 27, your crew will cease work on the Merrill Branch and work back over the north canal, from the Branch juncture to the lower intake, making these changes:

1 Widen the ditch 1 ft throughout from Wagner Creek to Merrill Branch, throwing all dirt to the east side. Preserve standard cross-section as far as possible (refer to specification sheet No. 1).

2 Remove lateral gates numbers 4, 5, and 6, and replace with standard 18-in. gates. Use 2-in. lumber in place of the 1½-in. stock in the present frames.

3 Erect two additional bents under the flume across Collier's Gulch, placing them near the centers of the two long spans.

4 Reinforce the canal at both ends of the Collier's Gulch flume with concrete and rock masonry. This piece of construction is at present not at all satisfactory.

We estimate that this work should be completed by May 18. If you find that your crew will be unable to finish it by that date, notify us in your report at least a week ahead, and we will send additional men.

Work on the south side will hold my attention for about ten days, after which I will return to your section.

Yours very truly,

W. H. McEllens

WHMcE/C

Supt. of Construction

3

FIELD ORDER No. 12

Job address Millville, Mass.

Date July 18, 1942

Smith Construction Co.
Worcester, Mass.

Attention C. B. MacNeil, Field Supt.

Gentlemen:

You are hereby directed to make the following changes in the construction of the receiver platform for the Vesta Knitting Mills:

1 Channels for side braces

Standard 10-in. channels, 30 lb per foot, will be substituted for the strip-iron braces proposed in the original construction.

2 Tie-rods and end braces

Four tie-rods will be used to strengthen the top of the platform. They will be 1 3/4 in. in diameter and run obliquely to the center line of the platform, as shown in the accompanying blueprint. The end braces will be 5 by 3 angles, 12.8 lb per foot, and will be placed on opposite sides of the end frames as shown in the drawing herewith.

3 Method of fastening

The side braces will be held at their outer ends by the tie-rods, with nuts and washers. Three-quarter-inch bolts and gussets will be used to fasten the lower ends of the side braces to the end braces as shown in the drawing.

Yours very truly,

WILSON & KNIGHT, INC.

Herbert A. Freeman
Resident Engineer

Encl.

4

RULES AND REGULATIONS FOR FIELD PARTIES

The Field Engineer is in complete charge of his men and must see that no one questions his authority. He should be fair and strictly impartial in his decisions; there should be no wavering on his part and his men should clearly understand that the Field Engineer's decision is final, and make no attempt to have the question referred to headquarters.

The Field Engineer is held strictly accountable for all his actions in performance of his duties.

In the absence of the Field Engineer the next ranking man will take charge, so that the work may proceed without interruption.

The regular time for the men to start work is 7 a.m. All the men should get up at the same time in the morning. Those who are working regularly in the field office may, in the Field Engineer's discretion, be allowed time off to take exercise.

The Field Engineer should assign one of his men to call for the mail both in the morning and in the evening.

Field Engineers should send in expense accounts at regular intervals, usually every two weeks, and should see that the men have paid their part of the board bill when due.

Field Engineers are required to keep a diary (form 2016 is suggested) showing the movements of and work performed by each man. This diary should be preserved for several years.

When establishing a field office, or when moving the office, the Field Engineer should immediately notify headquarters of his post office address and his telephone number.

2

The Field Engineer will make a weekly report, which must be received at headquarters on or before Monday morning.

Report should show work performed during the week, absences from work, and anything else of major interest; also work on hand but not under way. Make report succinct and limit yourself to one sheet if possible.

At the bottom show percentage complete of the following items:

Line
Levels
Topography
Property Lines
Map
Profile
Cross-Sections
Right-of-Way Plats
Estimate
Also —
Length of Line
Number of Men

A FEW SUGGESTIONS

1 The best results are usually obtained by dividing the force up into small units and by having each man follow his work to a conclusion.

2 Keep your outfit in complete repair and wear out the old things first.

3 Finish the work as you go. Field notes not platted and maps not on tracing cloth are useless.

5

WAYS TO SAVE WELDING ELECTRODES FOR PRODUCTION[9]

Millions of pounds of precious electrode metal can be saved by sound welding technique, plus horse sense; Clayton B. Herrick, Lincoln Electric Co. welding engineer, tells how.

The national need to conserve materials (particularly metals and alloys) is reaching an acute stage. Welding is a key process in the high-speed production of ships, planes, and a great variety of other equipment. Such uses are today consuming thousands of tons of high-quality welding electrodes. Always a matter of good business, the efficient use of electrodes and electrode metals now becomes a matter of patriotism as well. Electrodes must do a 100% job in production.

Here are suggestions for saving electrodes without impairing work quality. In most cases they will improve quality as well.

Sixteen Ways to Save

1 Select the right type of joint and be careful of fit-up. Some joints take much more metal than others. It will often happen that the joint taking less metal will be as suitable, or perhaps more suitable, for the particular purpose. Close fit-up will save a lot of money and metal. For example, if deposited metal costs $1 per pound (including current and labor for two beads) the cost per running foot of joint of Tee-weld, with ¼-in. plate, will be 40 cents if the plates are well fitted. If bad fitting produces a ⅛-in. gap, the cost will be increased to 80 cents per running foot.

2 Choose the correct electrode. While the general-purpose electrode will produce satisfactory welds under most conditions, special electrode may prove better for certain work. Consider physical properties required, joint, position of welding, condition of fit-up. Then follow the manufacturer's advice.

3 Use an electrode that has and maintains a uniform coating. To a large extent the coating controls the weld quality. Poor coating ruins welds and wastes electrodes.

4 Use electrodes that provide proper physical properties.

5 Use fast-flowing electrodes wherever possible. Here the saving is chiefly in time, rather than material.

[9] *Power*, Vol. 86, No. 4 (April, 1942), p. 102. A good example of the writing of instructions, which may or may not be in letter form.

2

6 Select an electrode that keeps splatter and slag loss at a minimum. All splatter is a waste of weld metal. The splatter loss of electrodes varies; so avoid those having excessive losses.

7 Wherever possible, use electrodes that produce flat beads. It is a waste of electrodes to deposit more metal than is needed and a waste of time to remove the excess metal.

8 Select the right size of electrode. The largest diameter electrode that can be used effectively is the best for conservation. The weight saving may run up to 40%.

9 Use long electrodes. If the electrode is long, a given stub length is a smaller percentage of the total. Thus, the monthly waste in stubs is inversely proportional to the original length of the electrodes. For ¼-in. diameter or larger, use 18-in. length.

10 Do not bend electrodes. This generally unnecessary habit will waste a quarter to a third of the electrode. Use the electrode straight and get the maximum of deposited weld metal from each rod.

11 Use proper voltage and current setting. Incorrect settings mean excessive splatter loss or inferior weld.

12 Follow the procedure specified for the electrode. Accompanying each electrode manufactured are detailed specifications regarding procedures to be followed. Follow them to prevent waste and assure high-quality welding.

13 Avoid using an excessive number of beads. Don't use two where one will do, or three where two will do.

14 Use electrodes down to minimum stub end. Remember that the electrode can be used the entire length of its coated surface. Leaving any more than a minimum stub end is an obvious waste. By using care in gripping the electrode at its extreme end in the holder and burning it down to the maximum extent, the operator is rendering a patriotic service. Just ½ in. saved in a stub end means 3½% on an 18-in. length rod. An accumulation of welding stubs in one shop was sampled recently and showed an average waste of 17%. For the time covered this amounted to $268.

15 Save stub ends of electrodes. High-class scrap is precious. At the present rate of welding for war production, the metal that would be wasted by failure to save stub ends would be tremendous. The average stub end is 2 in. long. Multiplied by the millions of electrodes used, this would constitute a great loss if all were thrown away.

16 Use modern high-capacity welding generators. Welding generators manufactured today have much higher capacity and much greater efficiency than earlier models.

Letter of transmittal. A letter of transmittal often accompanies a report or other document, partly as a matter of courtesy, partly as a matter of record. The retained copy of the letter shows when, to whom, and by whom the report or other document was sent. A letter of transmittal is always brief and formal.

HALSEY, KIRBY & CO.
Engineers

St. Louis, Missouri
June 10, 1942

Mr. S. A. Adamson, Vice-President
Brackett Manufacturing Co.
Hainesville, Missouri

Dear Sir:

At your request we have made an examination of the power situation at your plant and have studied the conditions with a view to obtaining improvement in your power output.

We are sending to you the report outlining the existing conditions and our recommendations for changes to be made at your power plant.

Yours truly,

HALSEY, KIRBY & CO., ENGINEERS

Everett James

EJ:BVA
Encl.

Letter of authorization. The letter of authorization may be an ordinary typewritten letter, or a printed form, to be forwarded, when completed, to the contractor or other person who is about to undertake a job. It is sometimes accompanied by a general contract, a printed form not illustrated here, since it is usually drawn up under legal advice.

A. B. CASSELL, INC.
Industrial Engineers

File No.
13,187:E.E.

Our Contract No. 865
Your Contract No. 339 B
Commission No. 2430

Date April 4, 1942

To Birschfeld-Watters Electric Co.

Address 214 Acton St., Syracuse, N. Y. (Contractors)

You are hereby authorized and instructed to furnish all labor and material required to perform for our Clients The General Wire Co. Address Detroit, Mich. (Owners) the following work, subject to the general contract, conditions hereto attached and made a part hereof:

> Install complete system of wiring for power and lighting in the extension to the manufacturing building at Detroit, Mich., in accordance with specifications C-801 entitled "Light and Power Wiring — Manufacturing Building Extension — General Wire Co., Detroit, Mich.," and plan C-201, all dated March 15, 1942.

CC to
Contractors
Owners
Resident Engineers
File

A. B. CASSELL, INC.
John Martin, Treas.
Duly authorized agents of Owners

Interdepartmental memoranda. Memoranda between departments or between members of the same department are, in many large firms, written in military form. Such a practice insures that the memorandum shall be a complete item of record. In the body of the memorandum a certain degree of informality is permitted and completeness of treatment is often unnecessary, because both writer and recipient are equally familiar with the subject. Such communications between or within departments or between the home office and branches are characterized by

1 Compactness and brevity
2 Absence of some of the formalities and amenities of the

ordinary business letter, of all matter except that which comes within the limited scope of the communication

3 Omission of salutation and complimentary close

4 Use of short paragraphs, often paragraphs of isolated statement.

The specimens which follow illustrate various kinds of such communications.

1

Monroe, Indiana
January 12, 1943

FIELD LETTER No. 5
OPERATION OF CRANES

Effective immediately the following procedure shall be followed in every respect on all work involving the use of crane equipment:

1 No such piece of equipment shall be operated under any condition unless there is present a signal man whose sole function is to watch the operation of the equipment and men incidental to such equipment operation.

2 This signal man under no condition shall at any time turn his back to the operation of the crane or assist in any manner with the work that may be in progress, but shall devote his entire time to signaling the operator and watching all conditions in and about the operation.

3 At such time that a gang foreman is performing the function outlined above, the signal man shall then be permitted to assist with the work.

4 Crane operators are instructed that they are not to operate a crane unless the signal man is present and functioning as required.

5 It is the responsibility of all members of the organization to follow this procedure closely and report any violations to the proper supervisor.

[G. R. C.]

GRC:FMF

2

Date January 14, 1942

TO: All Department Superintendents

1 The operation of the Hardin Plant requires a full complement of men, twenty-four hours a day, seven days a week. Regularity in attendance is required of all employees.

2 Unexcused absences or absences on which the management received insufficient notice to provide relief will not be tolerated. Undoubtedly, there will be emergencies when an employee cannot call about illness or other problems which prevent him from reporting for work. These emergencies, however, will be very infrequent. Absences after pay day or over the week end are always questionable.

3 Absence for illness or other emergency should be reported at least eight hours before the start of the next shift. Absence for unimportant personal convenience or recreation will be considered at the convenience of the management and should be requested at least two days in advance.

4 This problem is most important. We cannot tolerate men who are irregular in attendance. The attached notice will be posted in the areas, and it will be the responsibility of the Foremen to see that the men are acquainted with and observe these regulations.

5 Obviously, the supervisors and foremen will observe the same regulations.

SIGNED____________________________

3

February 1, 1941

Mr. J. R. Jones
Mandel Works
New Haven, Connecticut

MISCELLANEOUS BUILDINGS

Supplementing recent correspondence and conversation in regard to Change Houses, we regret that it has taken some time to determine the needs of the Transportation Department. We present below the conditions which we expect to have to meet and our own recommendations.

It is agreed that Change House, building #5, will be used for the labor crew of the Transportation Department. We should like very much to have a partition put in this Change House in such a way as to provide desk space for the General Labor Foreman and one clerk, obtaining this space at the expense of locker space. We recall that you indicated that such a change could be made without a new drawing.

We mentioned to you on your recent visit our need for a Change House in the general vicinity of the present yard office, building #5, this Change House to accommodate one hundred men. This you felt could be taken care of as an addition to the yard office. Such an arrangement would be entirely satisfactory to us.

We also mentioned to you the need of a Change House for two hundred men to be located as close as possible to the main garage, building #5. In connection with this need we should like very much to have, either as a part of the building or as a separate building, office space for at least nine people. Of these, it would be helpful if three could be in one room and six in another. We cannot afford to sacrifice any locker space in the Change House, as we shall need to accommodate at least two hundred men; we would, therefore, request that an addition to this building be provided if at all possible in order to take care of this needed office space.

Will you kindly let us know promptly whether these needs can be taken care of in the manner suggested or whether you have other means which are preferable?

[G. R. C.]

GRC:FMF

Sales letter. Although it is not probable that students in engineering will go very far in the study of the sales letter, a form of communication which has a very special technic and admits of a great variety of methods of appeal, it is desirable that every engineer should have some practice in applying the general theory in his own particular field.[10] The fundamental characteristics and requirements of this form may be briefly summarized:

The writer of an engineering sales letter must know his product thoroughly in order to talk or write about it intelligently and convincingly.

It is also desirable, when possible, to know the prospective customer's point of view—that is, the amount of information or precise knowledge which he already possesses regarding the article in question, his attitude toward it, and the scope and particular nature of his need.

The letter must then, according to the general principles which are now universally followed—

1 At the outset, if possible, attract the attention and arouse the interest of the prospective customer, this primary essential to be striven for without the use of overstatement or sensational methods of appeal.
2 Create or stimulate a desire on the part of the customer and a belief in the efficacy of the product.
3 Convince the recipient that the use of the product would be to his advantage.
4 Persuade him that he ought to purchase at once—that is, lead to immediate action.

A successful sales letter impresses the reader, first of all, by the neatness and attractiveness of its arrangement. It is simple, direct, and concise in its phrasing; dignified, sincere, and truthful in character. It maintains, throughout, the "you attitude"—that is, the regard always for the interest, the particular needs and special conditions, of the prospective customer.

Of the specimens of sales letters which follow, numbers 1 and 2 are student themes in which the authors attempted to apply the foregoing principles.

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[10] Students who desire special instruction in this form of letter writing should refer to such books as Babenroth and Parkhurst, *Modern Business English*, third edition, Prentice-Hall, Inc., 1942, pp. 197-319; and Smart and McKelvey, *Business Letters*, revised edition, Harper & Brothers, 1941, pp. 252-409.

1

[A student theme]

EDISON STORAGE BATTERY COMPANY

Orange, New Jersey

November 12, 1941

Wilson Line
Chicago, Illinois

Attention of Purchasing Agent

Gentlemen:

Our attention has been directed to the fact that you are planning to purchase a fleet of electric trucks for use at your Wilmington station. We are sending you our monographs, numbered 500, 600, 803X, and 503X, with the hope that the facts presented in them will aid you in selecting the proper storage battery for use in your trucks.

The Edison Alkaline Storage Battery has the following distinguishing characteristics:

I Efficiency: The actual working-efficiency of this battery averages 82 per cent.

II Cost

A Purchase price: The purchase price of this cell, $10, is slightly above that of the acid storage cell.

B Charging cost:

1 A 7-hour charge per cell in batteries of 12 cells costs $0.024.

2 A 7-hour charge per cell in batteries of 60 cells costs $0.0048.

Wilson Line
Nov. 12, 1941
Page 2

C Other items: Depreciation and annual upkeep are figured at $1 per unit.

III Physical characteristics

A Durability: The manufacturer's tests assure the buyer that the cells will withstand practically all ordinary mechanical or electrical mistreatment.

B Weight: The cell is light in weight and the power unit in the trucks is consequently compact.

C Standard design: The Edison Alkaline Storage Battery has been manufactured without change of design during the past five years.

IV Performance: The Bush Terminal Company of New York, the world's largest freight-handling concern, uses Edison Alkaline Storage Cells exclusively in its electric trucks.

We should be pleased to send one of our technical experts to look over your specific requirements and to advise you concerning the purchase of your storage cells.

Very truly yours,

EDISON STORAGE BATTERY COMPANY

William Dare Scudder

Manager, Service Division

2

[A student theme]

HENRY WILD SURVEYING INSTRUMENTS SUPPLY CO. LIMITED

HEERBRUGG, SWITZERLAND

November 12, 1941

Rutgers University
New Brunswick, N. J.

Attention: Mr. John Doty, Professor of Civil Engineering

Gentlemen:

I understand that you are planning to purchase a new surveying instrument for use in your surveying classes. Enclosed is a pamphlet describing and illustrating the different Wild instruments.

Wild instruments are universally preferred to all others on account of their reliability, accuracy, and simplicity and rapidity of manipulation. A few of the many characteristics of these instruments are as follows:

1 Manipulation

Even in the smallest and simplest instruments of the Wild construction, all operations at the instrument should be possible without the observer's having to move from the sighting position.

2 Correctional adjustments in the field

Through the careful selection of materials used in their construction, adoption of compact forms capable of offering great resistance to outside influences, and precision in manufacture, it has been found possible to construct instruments which (with ordinary care in handling) require no field-adjustment.

3 Luminosity

Wild has emphasized the importance of luminosity in the telescopes of surveying instruments. High magnification is of no use if it cannot be obtained when the weather is dull or when sighting conditions are bad.

Rutgers University
Nov. 12, 1941
Page 2

4 Internal focusing

All Wild telescopes have internal focusing, which enables them to maintain a constant length and offers protection against outside influences.

5 Graduation—reading

In Wild instruments all graduation circles are read by means of an optical micrometer. These micrometers are extraordinarily stable and resistant to outside influences, and their accuracy is truly astonishing. Readings can be made by estimating to one minute with certainty.

6 Weight

Wild has combined all his instrumental improvements into an instrument which weighs less than half as much as the corresponding instruments of the older types.

7 Metallic case

The metallic case for the Wild instruments shows great superiority over the old wooden cases, in regard to durability, lightness, and complete watertightness.

On your request, I shall furnish any details and prices, or shall visit your University at any time that is convenient to you.

Very truly yours,

[D. F. H., Jr.]
Company Agent

Local address:

19 East Summit Avenue
Richardson, Virginia

3

EVINRUDE MOTORS

EVINRUDE - ELTO

Milwaukee, Wisconsin, U.S.A.

Motor No. 4368-00931

I HAVE BEEN WONDERING
HOW YOU LIKE YOUR NEW

outboard motor which you purchased recently, according to the Registration Card which you returned.

Our interest, you know, does not cease when you have purchased one of our motors. It really only begins then, because our most valued file here is the list of most of the one-half million Elto and Evinrude owners dating back over a period of years, during which many owners have purchased several motors. Those repeat purchases were made on the strength of the performance of the first motor. We, of course, hope to sell you your next motor.

But right now, we have nothing to sell. This is just a friendly message to help us to become better acquainted. We're interested in you and that motor of yours. We feel the same sense of responsibility for that motor as you do when you recommend a friend of yours for a responsible position. We recommended that motor to you through our catalog, our advertising, and our dealer.

And now that you've had a little time in which to become acquainted with your motor, we're wondering how you like it.

We have a service department here and approximately 50 authorized service stations throughout the country, through which we can serve you. I know we can help you derive as much enjoyment from your motor as these other owners.

So drop us a line today. And continue to keep in touch with us. We'll always be glad to hear from you.

Yours very truly,

EVINRUDE MOTORS

W. C. Clausen

Vice-President

4

GENERAL ELECTRIC COMPANY

SPS-K219

For uniform, high-quality resistance welding, it is important that you adjust your welder for the right current and time on. It is also important that your welder be adjusted to provide the right electrode pressure.

The new G-E electrode-pressure gage, described in the attached leaflet, enables you to determine quickly and accurately the electrode pressure on a spot, seam, or projection welder.

Here are two ways in which it can prove valuable:

1 After the setting up of a welder for a high-production run on a particular material, it is important that the pressure be maintained constant throughout that run in order that the quality of your product will be uniform. The gage can be used to test electrode pressure at intervals to make sure that it remains constant.

2 Once a material has been successfully welded, that same material can be welded with corresponding results at a later date or in another plant if the values of current, time, and electrode pressure are duplicated.

If you are using resistance welding equipment on a production basis, you will find the G-E electrode pressure gage a valuable aid in producing more uniform welds and in reducing rejects. The resulting savings can in a very short time amount to several times the purchase price of $145 net.

Why not send us your order now? We can make stock shipment, subject to prior sale.

Very truly yours,

Kenneth Carlin

KC:BJ

5

[A group of brief sales communications]

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

Progress requires persistent research for better methods and better materials.

One of the fruits of our research is Prestite, a material that promises improved insulation and ease of assembly in many applications. The following pages make a comparison between Prestite and wet and dry process porcelain. There may, possibly, be other forms of insulation now in use in your plant that can be advantageously replaced by Prestite.

I shall be glad of an opportunity to discuss your applications with you.

Very truly yours,

M. C. Smith

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

Save! Save! Save!

. . . that is the byword of the times, and Westinghouse stokers, even in anticipation of present-day conditions, have had economy as their objective for decades. For instance:

Economy in operation—Link-Grate stokers can burn any grade of bituminous coal, often a cheaper grade than formerly used.

Economy in maintenance—Link-Grate stokers last longer by eliminating hot spots in fuel bed.

Economy in installation—Special features of both single and multiple retort save time and excavation expense.

The following pages illustrate exclusive advantages of our design that mean lasting economy over many years of service. Are you assured of similar savings with your present equipment?

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

"Heat with electricity? Not when we have plenty of process steam to do the job."

Quite right, but there are many spots where steam cannot be economically piped—for instance, watchmen's houses at gate entrances, storage yard sheds, crane cabs, and the like.

Those are the places where an electric heater, such as those described in the enclosed folder, can be used to advantage. They are safe, sturdy, and ideal for either temporary or permanent installations.

Why not determine now where safe, dependable heat can be used to advantage in your plant instead of waiting until cold weather arrives? If you desire, I'll be glad to show you one of these heaters in order that you may see how ruggedly they are built.

Letter of inquiry. The letter of inquiry calls for little explanation. The inquiry should always be so phrased that there can be no doubt as to the exact information desired. Make your questions clear, direct, specific, and complete. If the questions are numerous, they should be tabulated and numbered for convenience in answering. The following is a simple inquiry about prices:

June 22, 1942

Chippewa Mills, Inc.
242 West 36th Street
New York City

Gentlemen:

Will you please quote us your price on waterproof and washable arm bands to be used by persons on the campus in connection with our centenary celebration? We should like the arm bands to be gold in color, imprinted in blue with "U. of C." Please quote us on a quantity of one hundred.

Very truly yours,

Ronald Drew
Business Administrator

Quotation letter. A quotation letter is always in answer to an inquiry about prices. It should be mailed promptly. If it is impossible to make the required reply at the time, an acknowledgment of the inquiry should be sent immediately, together with a definite promise of a further letter. Care should be taken to thank the correspondent for his inquiry. The customer's requirements should be met, exactly and fully.

June 24, 1942

John Dill Co.
P. O. Box 142
Decatur, Indiana

Attn: Mr. R. A. Henderson

Re: X. Y. Z. Company

Gentlemen:

We submit herewith quotation for the furnishing of registers necessary to complete the ventilation in the men's and women's rest rooms as shown on revised blueprints dated April 28, 1942. This change, involving the registers, necessitated a slight change in the duct work in the men's rest room, for which an allowance has been made and considered in the following price:

Registers	243.00
Less change in duct work......	40.00
	203.00
Plus 10%	20.30
	$223.30

Please let us hear from you at your earliest convenience, as the registers will have to be ordered. According to the estimate of the sheet metal contractor, several weeks will be required for delivery.

Yours very truly,

A. H. Wolters

AHW:LB

Copy to: N.K.O.
Philadelphia, Pa.

Order letter. The order letter, like the letter of inquiry, should take particular pains to make clear exactly what is wanted. It should include not only a full description (tabulated if necessary) of the article or articles to be furnished, but also specific instructions as to date and manner of shipment, price, and terms. The first specimen is a form used by an architectural firm in placing important orders for clients; the second is typical of order letters involving small amounts.

1

THE OFFICE OF CHARLES Z. KLAUDER

Architects

1429 Walnut Street, Philadelphia

September 17, 1941

RE: Men's Dormitory, University of Delaware

LETTER ORDER

TO: MILLER BROS.
WILMINGTON, DELAWARE
(Local Agents and Distributors, representing Simmons Company in all conditions herein stated.)

This Letter Order in being signed by responsible officers of the University of Delaware will serve as a contract between yourselves and that Institution under which you are to manufacture, finish, deliver, and set up in the various rooms of the new Dormitory Building, on the Campus of the University at Newark, Delaware, the following:

(A) The 86 Beds hereinafter scheduled and by reference described.
The net contract price of this Item is. . . .$ 903.00

(B) The 86 Beauty Rest Mattresses, to fit the Beds to be provided, and as hereinafter mentioned. The net contract price of this Item is 1,744.18

The total net contract amount of this Order is therefore $2,647.18

It is understood that the material covered by this Order will be manufactured promptly in order to avoid any delay in immediate installation when the building is ready for occupancy,

and is either to be held in storage by you for shipment on notification by the Owners, or may be shipped to the University as completed for storage in spaces provided on the campus. If the material is stored by the University, all handling and insurance coverage are to be provided for by you under your own responsibility until the material is installed in the completed building and accepted by the University authorities.

The terms of payment are to be 85 per cent when all the material embraced by this Order shall have been completely installed in the building, and the remaining 15 per cent thirty days thereafter.

FOR UNIVERSITY OF DELAWARE

Approved:
THE OFFICE OF CHARLES Z. KLAUDER

Accepted:
MILLER BROS.

2

Hobson, New Jersey
March 12, 1942

Charles J. Field's Sons
635 Market Street
Philadelphia, Pa.

Gentlemen:

Please send me by Parcel Post and charge to my account the following items:

Cat. Page 438 One-half ream No. 1 Garnet Paper
" " 472 100 Hex. Cap Screws 1/4-in. diam by 1 1/2-in. length
" " 482 One gross 3/8-in. Hex. Nuts Finished

I should be very glad if you could ship this order before March 18.

In making out your invoice, will you kindly bear in mind that according to a previous agreement with you, I am entitled to a discount of 20%?

Very truly yours,

Holloway Mason

Claim letter. The chief requisite of a claim letter is that it shall present the facts definitely and fully. It should be accompanied by documents, such as a copy of the bill of lading, in substantiation of the claim. A printed form is often used.

PEARCE FIREPROOF COMPANY
Fireproofing Building Materials
1911-13 North 2d Street
Philadelphia

October 6, 1942

Colonel M. E. Gilmore
2 Lafayette Street
New York, N. Y.

Dear Sir:

From March 21, 1942, up to August 22, 1942, we shipped to Mr. Richard Jameson, Plastering Contractor, c/o The Union Engineering Company, the University of Delaware, Newark, Delaware, materials totaling $2186.04, for which as yet we have not received payment.

Mr. Jameson informs us that he had requested and authorized the Union Engineering Company to make payment to us for materials during the month of August, and now we understand that this money is being withheld pending settlement of some differences between the plastering contractor and the general contractor. We have sent to the Union Engineering Company notarized statements and also a letter from Mr. Jameson again authorizing payments to be made.

As this money is now long past due, we are taking this opportunity to put this claim on record with your office against this job, and we shall appreciate it if you will be so kind as to inform us how we may obtain payment without further delay.

Yours very truly,

PEARCE FIREPROOF COMPANY

James A. Peters

JAP:ES
Copy to:
Harry E. Tunnell
c/o University of Delaware
Newark, Delaware

Follow-up letter. The follow-up letter is of many different types. One has already been illustrated under the letter of application (p. 174). Another common type of follow-up is a letter written at an interval after the sending of a sales letter or a quotation letter, if no order is forthcoming. Such a letter is, in effect, another sales letter. The following specimen illustrates a broader theory of the follow-up: that the service performed under a contract does not terminate with the completion of the contract but takes the subsequent form of a cordial and continuing interest in the welfare of the client.

AMIDON, KENT AND COMPANY
Engineers

NEW YORK
CHICAGO
PHILADELPHIA
ST. LOUIS

318 HOLLEY BUILDING
ST. LOUIS, MO.

November 30, 1942

Mississippi Traction Company
Terminal Building
St. Louis, Mo.

Attention Mr. Albert E. Polk

Gentlemen:

We should be very glad to know if the Cost Manual recently sent you meets your requirements. We want you to feel that our interest in your problem did not cease with the written report, and that we are anxious to give you a working plan that you can and will use. We shall be pleased to call and go over the details of the Manual with you.

Very truly yours,

AMIDON, KENT AND CO., Engineers

FRK/MFB F. R. Kendall

Letters in series. The following letters illustrate the way in which a number of letters may be linked into a complete and continuous correspondence. One of the later letters in the series

is a report in letter form. As stated before, it is impossible, in engineering correspondence, to separate completely letters and reports.

1

PATTERSON LUMBER COMPANY
Ontario, Oregon

May 1, 1942

Moore & Prentiss, Engineers
505 Mason Building
Portland, Oregon

Gentlemen:

The Patterson Lumber Company is planning to extend its operations within the next year, following the purchase of the Barrington tract of timber (about 16,500 acres) in northern Malheur County. We have been operating only the one mill at Ontario, and have been doing our own logging on a small scale in our adjacent holdings. The proposed extension will include the construction of a railroad from Riverside to Barrville, with a number of spurs; the erection of a new mill; and the establishment of three camps.

We find that there are no adequate or even accurate maps of the area, such as we need as a basis for our plans. With a view to securing a complete set of maps, we have studied various mapping systems, and believe that the one outlined in your pamphlet on Topographic Logging Plans is admirably suited to our needs. However, we have no men in our present employment familiar with this work, and we should like your firm to take the contract of mapping the tract.

We desire that the maps be completed by August 1, as we plan to begin actual construction work shortly after that date. If you can consider the contract, please notify us and send an engineer to inspect the area and arrange terms and details.

Yours very truly,

PATTERSON LUMBER CO.

L. J. Harris
General Manager

2

MOORE & PRENTISS

CIVIL ENGINEERS

505 Mason Building Portland, Oregon

May 4, 1942

Patterson Lumber Co.
Ontario, Oregon

Attention Mr. L. J. Harris

Gentlemen:

In reply to your letter of May 1, we assure you that we shall be glad to consider the contract for mapping the area described, and believe that our topographic system will give you the results you desire.

We are instructing Mr. R. F. Hobson of Baker City, a capable engineer with previous experience in this work, to proceed at once to Ontario, where he will confer with you, examine the area, and determine the terms of the contract. He should be with you on May 8.

We enclose for your information one of our standard contract forms. The specifications stated are subject to considerable modification as you may desire.

Very truly yours,

MOORE & PRENTISS

F. B. Moore

Chief of Engineers

FBM/MLC
Enclosure

3

MOORE & PRENTISS
CIVIL ENGINEERS

505 Mason Building Portland, Oregon

May 4, 1942

From: F. B. Moore

To: R. F. Hobson, Res. Engr.
Baker City, Oregon

Re: Patterson Mapping Project—preliminary instructions

1 The Patterson Lumber Co. of Ontario has asked us to take the contract for mapping the Barrington tract of 16,500 acres in preparation for their logging operations in that area. We have accepted the offer, subject of course to agreement on terms.

2 We have chosen you to investigate this proposition, to complete necessary arrangements, and to conduct the survey. You will proceed to Ontario in time to be there on May 8 for conference with Mr. L. J. Harris, their general manager.

3 After ascertaining their specific requirements. you will personally examine the area in a general way and determine what you deem a satisfactory contract price. Your conclusions will of course be based on a comparison of this project with the others you have conducted in eastern Oregon.

4 Wire us not later than May 11, stating contract price decided upon and any extraordinary features of the undertaking, before reaching any agreement with the Patterson Company.

5 If terms are approved by us, draw up standard contract (we enclose form), secure its acceptance, and await further instructions.

F. B. Moore
Chief of Engineers

FBM/MLC
Enclosure

4

Baker City, Oregon
May 6, 1942

From: R. F. Hobson

To: F. B. Moore, Chief Engr.
Portland, Oregon

Re: Patterson Map Project—receipt of instructions

Your letter of May 4 was received today. I will carry out instructions as outlined.

R. F. Hobson
Resident Engineer

5

Ontario, Oregon
May 11,1942

From: R. F. Hobson

To: F. B. Moore, Chief Engr.
Portland, Oregon

Re: Patterson Map Project—report on contract

1 In my telegram of today, I recommended a contract price of thirteen cents (13c) per acre, and stated that the only exceptional item desired is the preparation of several extra sets of double scale maps. The relatively high price is due chiefly to the inaccessibility of the tract. It is not very rough country, the general topography resembling that of the Dry River region mapped last year.

2 Your telegram of approval is received. I have presented the completed contract form to Mr. Harris, who seemed well satisfied. He will undoubtedly secure its acceptance tomorrow. I will wire as soon as I have the definite acceptance.

R. F. Hobson
Engr. in Charge

MOORE & PRENTISS

CIVIL ENGINEERS

505 Mason Building Portland, Oregon

May 14, 1942

From: F. B. Moore

To: R. F. Hobson, Engr. in Charge
Ontario, Oregon

Re: Patterson Map Project — instructions No. 2

1 Your letter of May 11 and telegram of May 12 reporting acceptance of contract have been received. We are pleased with the prompt action secured.

2 You will now assemble crew and equipment, establish camp, and begin primary control survey without further instructions.

3 Time Limit. Though the contract allows us until August 1, we desire that all field work be completed not later than July 15, as we expect to have another project ready for you at that time.

4 Crew. It will be necessary to employ a larger crew than is customary. We are transferring four experienced men, including one good transitman, from the Jackson-Barnes crew. They will arrive in Ontario on May 18. You will need at least five additional men. We hope that you can secure the services of those who were with you at Homestead.

5 Equipment. The camp outfit at present in storage at Baker City will be shipped to you. Check over, and make necessary additional purchases of equipment as well as all supplies on our credit.

6 Reports. Bi-weekly reports will be rendered as usual.

F. B. Moore

FBM/MLC Chief of Engrs.

7

Ontario, Oregon
May 18, 1942

From: R. F. Hobson

To: F. B. Moore, Chief Engr.
Portland, Oregon

Re: Patterson Map Project — preliminary report and supply request

1 In compliance with your instructions of May 14, I have assembled a crew of eleven men, including the four transferred, who arrived today. Camp equipment from Baker City arrived by truck this noon and is being checked over. Supplies have been purchased and sent to our first camp site. We will establish camp tomorrow and Sunday. Transportation from Riverside is chiefly by pack train.

2 Please send additional instruments and supplies as follows:

2	F. S. Type Compasses
4	Abney Hand Levels — Topog. Scale
3	2-chain Steel Trailer Tapes
8	Field Notebooks No. 156A
4	Field Map Boards 8 by 10
1000	Standard Field Map Sheets

It is important that these reach me by June 1; until then, by proper distribution of duties, the crew can be kept busy with present equipment.

3 Send supplies and address future communications to me at Riverside, Oregon, the post office nearest to our camp.

4 Details of organization, procedure, and progress will be outlined in my first regular report, May 26.

R. F. Hobson
Engr. in Charge

8

MOORE & PRENTISS

CIVIL ENGINEERS

505 Mason Building Portland, Oregon

May 21, 1942

From: A. K. Leslie

To: R. F. Hobson, Engr. in Charge
Riverside, Oregon

Re: Patterson Map Project — shipment of supplies

Supplies as requested by you in letter of May 18 are being expressed to Riverside, with the exception of 4 Abneys and 3 Trailer Tapes. These will be sent you direct from Crane & Wells, Seattle. Invoice for our shipment is enclosed.

A. K. Leslie
Supply Manager

Practical Suggestions on Dictating[11]

1 Before dictating to a stenographer or dictating machine—
- a Decide definitely on the subject or subjects to be covered in the letter.
- b Have in mind or on paper a rough outline at least of your communication. Unless you have become through much practice a skillful dictator you may find it desirable to make a tentative draft of your whole letter.
- c According to the parts of your outline, order your material with reasonable definiteness according to paragraph divisions.
- d In the background of your consciousness, have the beginning and ending you will probably use.

2 In the actual process of dictating—
- a Phrase your sentences mentally before giving them orally.

[11] For ampler discussions, see Anne Boone, *Modern Business Letter Writing*, New York, 1937, pp. 110-117; and Naether and Richardson, *A Course in English for Engineers*, Boston, 1930, Vol. 2, pp. 421-429.

b Be sure that the one main idea of each sentence stands out clearly. Subordinate in phrases or clauses the elements which modify (restrict, amplify, or emphasize) the main clause or clauses.

c Vary the beginnings of your sentences by the use of adverbs, phrases, subordinate clauses, and leading independent clauses.

d If possible, have strong words or phrases at the ends of sentences.

e Be sure that your paragraph divisions represent parts of your communication which for your particular purposes should stand by themselves. A mechanical division on the written or printed page, which we call a paragraph, may consist of a single statement, a series of statements which you wish the reader to have before him at a single moment, or a logical development of a thought in several sentences which follow one another coherently. In this last kind of paragraph, you need to pay particular attention to your connective elements (words, phrases, subordinate clauses). See Chapter 2.

f Use good beginning and ending sentences in your paragraphs (connective, emphasizing, topic).

g Indicate clearly to the stenographer—
   (1) The beginnings and endings of your sentences and paragraphs; i.e., say, "Period" or "Paragraph."
   (2) Marks of punctuation within your sentences. You should probably not rely entirely on your stenographer for proper punctuation to bring out your meaning.
   (3) Revision of the phrasing of a sentence which you wish to make (omissions, modifications, additions).

h Use all the necessary little words (prepositions, conjunctions, definite and indefinite articles).

i Omit the entirely unnecessary and often annoying sounds which many dictators utter between words and between sentences—"Er," "and a," "the eh."

j Speak distinctly. Indicate by the rise and fall of your voice the end of a main clause in a sentence as well as the end of the sentence itself.

k Spell out for the stenographer proper nouns or adjectives and other words with which the stenographer should not be expected to be familiar.

Exercises

A Criticize the following faulty letters on the basis of the points made in this chapter.

1

We have your postal of the 3rd inst., requesting literature and we accordingly take pleasure in forwarding under separate cover a copy of our general catalogue, a pamphlet describing our Automatic Heat Controller & Regulator and one of our New Process in Case Hardening.

Respecting the former, we direct attention to the index on page 25; also please see pages 4, 6 and 13 for the requirements of our system.

List prices are subject to terms and discounts page 207, but to Educational Institutions we allow in place of these a special 20%.

We manufacture many more size and style heating appliances than those given and if we are informed as to the size, kind and amount of work to be treated within a certain time, we will be in position to make definite recommendation upon suitable outfit.

Our Automatic Heat Controller & Regulator is fully described in red-covered booklet, and we might advise that with its adoption temperatures of Gas Blast Appliances, using an air blast under pressure of from 1 to 1 ¼ lbs. to the square inch, are automatically controlled to within 50% of heat desired. This is guaranteed by us.

Price is as stated subject to discount of 5% 10 days, 3½% 30 days, or 2½% 60 days, f. o. b. our Factory at Elizabeth, N. J.

We consider the pamphlet covering our New Process in Case Hardening fully explanatory and state that with this process the packing of work in bone or other solid carbon is eliminated, the same being practically packed in a carbon gas, giving quicker and more uniform results.

The Machine and Process are sold under contract, copy of which is stated on page 25.

Any further details will be cheerfully given upon request.

Trusting the literature will be of interest and holding ourselves at your service,

Very truly yours,

2

Mr. W. R. Bales,
Supervising Insp.,
Philadelphia, Pa.

June
17th,
1941.

Dear Sir:—

Your letter of the 14th inst. is received and I have made note that the boiler which is intended to replace the old #3 boiler at the above works was given a shop inspection and test by Inspector Black on Wednesday, June 11th.

I have since received definite advices from the Phoenix Iron Works Co. to the effect that the new boiler was shipped on the 12th inst. and they presume it would arrive at our Assured's works not later than the 18th inst.

I shall make it convenient to journey out to the vicinity of our Assured's works before the close of this week, and will make note of conditions and progress being made towards the installation of the boiler.

I shall keep in touch with Mr. Campbell of the Assured who will advise me immediately upon their being ready to have the boiler put under steam, at which time I will make final inspection and hammer test.

Trusting this will meet with your approval, I am,

Yours respectfully,

D. Inspector.

3

Barton, Ohio
5-8-42.

Kewanee Insurance Company,
Philadelphia, Pa.

Dear Sirs:—

Referring to the long distance telephone conversation this morning with your office, we beg to confirm our quotation of $620.00 F. O. B. cars Meadville; shipments in about ten days, for one 72″ x 18′ bare boiler only, and to be a duplicate

of one of the six boilers furnished the Connellsville Central Coke Company in the fall of 1931. This boiler was constructed in three courses; 7/16″ shell; ½″ heads; longitudinal seam butt joint, with straps inside and outside and quadruple riveted. 72-4″ x 18′ tubes; armhole in front head below and above tubes, four steel brackets; 6″ nozzle, 9′ from the front head. The material we have in stock is for a two-course boiler which is the latest construction and we would have to place this nozzle 8′ from the front head. We of course understand exactly what is required and will furnish the boiler a duplicate of the previous one, except in regard to making it in two courses instead of three.

Awaiting your order,

Yours truly,

Acme Iron Company

P. E. Kill

Secretary & Treasurer.

4

Referring to our letter of February 27th in connection with your order 7489, our factory advises that they shipped you a replacement dust seal curtain on March 29th, but that the defective curtain has not been received at our Milwaukee Works. We would appreciate it very much if you will arrange to have this defective curtain returned at your early convenience so that our factory can inspect same and close our files on this order. The curtain with spacer rings should be returned to ——— Manufacturing Company. We would also appreciate it if you would send bill-of-lading covering shipment to this office so that we can notify the proper parties at our factory to watch out for the shipment.

5

With reference to your letter of October 30 regarding the status of the above order which had been placed with us on June 12, 1941, we wish to advise that we are unable to quote a definite shipping date because the order does not carry a preference rating.

According to the present defense setup, we cannot possibly concentrate undue efforts on non-defense orders since our shops are taxed to the limit in meeting the present schedules occasioned by the numerous priority jobs. We wish to inform, however, that this order had not been completely forgotten. We managed to salvage enough labor to keep up some progress.

Most of the major items which have been purchased from outside suppliers have been received except the bushings which have been ordered from Locke Insulator Company. These bushings were to be shipped October 31, 1941. We will check whether this shipment has gone forward and advise you accordingly.

At present, this transformer is scheduled to be shipped February 5, 1942 providing the priority situation does not become too acute which would necessitate rescheduling.

We would appreciate your efforts in obtaining a priority rating on this order since we are anxious to clear our valuable floor space in order to accommodate the ever increasing volume of defense work.

At present, the job is well through the stages of fabrication. The coils and core have been stacked, and the tank is finished. The next operation will be "connect complete" followed by vacuum drying, testing, and the final stages of production.

We would encourage the customer to obtain a priority rating on this job if the subject is justified in filing an application. If a preference rating of A-1-H is obtained, we could assure delivery on the fifteenth of January, 1942; an A-5 rating would assure the customer of consistent progress on the job until completion, the shipment dependent upon the number of jobs with higher ratings in our order book.

Please advise at the earliest possible date whether this order will carry a preference rating. Your cooperation in helping us during this critical period is greatly appreciated.

6

In reply to your communication of 5-16-41 accompanied by tabulation outlining the special construction features as pertaining to the various KVA and voltage ratings involved, we wish to thank you for this very complete information and to state that with Mr. ——— we have gone over these various points with Messrs. ——— and ———, engineers of the ——— Electric Company, with the result that it has been agreed that we should supply our present type transformers with double hangers in line with your chart of 5-15-41 which is approved by the customer's engineers with the exceptions that we do not need to limit to 12″ minimum, the clearance HV terminal and pole on 12 KV as there is no limit here, and with the further exception that cover bushings are not wanted on 16.5 kv transformers. If we do not now have a suitable pocket type bushing to offer this customer on 16.5 kv and can't get one in time for this order, we feel that we had better suggest to the customer that they cancel the eight transformers on the order in the 16.5 Kv class and make it up to us by giving us an additional quantity in the 2400-volt class. It is, therefore, requested that you advise us promptly as to whether or not you do have a satisfactory pocket bushing available for this order so that we may reach a final conclusion with customer. We did not think it wise to attempt to force the customer to again accept our cover bushing on these few units because they are very definitely opposed to using them, and they intimated that we would get more business by giving them what they want.

We are assuming that our present style, double hanger transformers will be the same in details as the transformers furnished on last order for this customer and that the quantity of oil, in gallons, will be shown on the name plate and that the interior construction will be the same, etc., etc. If there is any change, please do not fail to let us know immediately so that we may discuss same with customer and secure their approval.

On your tabulation we note you state that "tap changer to be supported on steel brackets" and we wish to again emphasize that this should not be overlooked.

In regard to the T-shaped ——— hanger and also the new type of hanger mentioned in paragraph four of your letter, we can say that we secured prints of the T-shaped hanger as made up by the ——— Manufacturing Company to meet the standard specifications and which we understand ——— and Company have agreed to make for ——— Manu-

facturing Company, and have concluded, after talking with Mr. ———, that it would be best to proceed as outlined above and furnish double hangers. The T-shaped hanger as shown on these ——— Manufacturing blue prints indicate that the transformer will be about 1″ lower from the cross arm than the ——— hanger and which, of course, conforms to Standard specification requirements.

We trust you will acknowledge, at your early convenience, that it will be satisfactory to you to proceed as indicated above, in which event it will not be necessary to discuss the new ——— type of hanger with the idea of getting customer to accept same on this order. We can and will, however, continue to sell the ——— standards to this customer with the hope in mind that possibly on the next order they will be willing to accept these standards provided, of course, we can keep them out of conflict with the standard specifications.

We hope you will let us have the tabulated performance data, recently requested, at a reasonably early date.

B Write one or more of the following letters. The study of catalogs and bulletins will help to furnish ideas and material for many of these exercises. Some catalogs contain instructions for ordering. Students may find it necessary, also, to ask for suggestions from instructors in engineering.

1 Letter of application for a summer position which you are qualified to fill
2 Letter of application in reply to an advertisement in a technical periodical
3 Letter of application to be sent to a number of companies
4 Letter to a prominent engineer inviting him to address an engineering society
5 Letter asking for information or advice
6 Letter of instruction from superintendent to foreman specifying how a given job shall be done and what materials shall be used
7 Instructions from superintendent to foreman specifying in detail changes to be made in plans for a piece of work
8 Instructions to chief draftsman directing how a detail of a drawing shall be worked up
9 Instructions from home office directing an engineer how to erect and operate a certain machine

10 Instructions from consulting engineer to resident engineer advising on method of procedure
11 Instructions from office of manufacturing firm directing work of salesmen
12 Set of standing instructions
13 Letter from an engineer arranging for a meeting of a body of businessmen to discuss an engineering project
14 Letter from an engineer to board of overseers to arrange for inspection of a completed or partially completed job
15 Letter from home office to construction engineer authorizing hire of additional laborers
16 Letter instructing a construction engineer to rush or to stop work
17 Field order from resident engineer to contractor ordering changes in job
18 Letter of transmittal accompanying report
19 Letter of transmittal accompanying lease of manufacturing property
20 Memorandum from engineer to personnel office requesting authority to hire additional laborers; state number and kind
21 Memorandum from construction engineer to chief engineer saying that he expects labor trouble, giving reasons and proposing plans for avoidance
22 Sales letter addressed to colleges and offering laboratory equipment
23 Sales letter designed to popularize the use of some technical equipment
24 Sales letter offering pump, lighting system, or other machinery to a Western farmer
25 Sales letter for engineering equipment with which you are familiar, addressed to a manufacturer
26 Letter asking prices on equipment or product
27 Letter inquiring about delayed shipment
28 Letter from contractor to engineer inquiring about some specific detail of construction job
29 Letter from manufacturer to consulting engineer inquiring about effectiveness of a certain type of apparatus, method of construction, material, or technical process
30 Letter requesting appointment for conference
31 Letter inquiring as to progress of a certain job
32 Letter to manufacturers inquiring whether they will duplicate order of certain date, with some changes; details of changes and drawings to accompany letter
33 Letter inquiring about size and cost of a jet condenser to operate with an engine of certain size and type

34 Letter inquiring about size and type of distiller to supply fresh water to marine boilers
35 Letter of inquiry resulting from a sales letter
36 Quotation letter
37 Follow-up of quotation letter
38 Follow-up of application letter
39 Follow-up concerning buyer's satisfaction with certain machinery installed
40 Follow-up concerning client's satisfaction with certain system or process recommended
41 Follow-up after failure to receive prompt reply
42 Letter ordering goods on which quotation letters were written
43 Letter of complaint regarding goods purchased
44 Letter adjusting complaint
45 Letter from an engineer to an electric concern stating that the motor installed by it is not giving satisfaction; clear explanation to be given
46 Letter to a repair shop stating that certain parts in the engine of a power plant have failed and asking that a man be sent to prepare sketches and submit estimate on repairs; also reply to this letter
47 Letter from a manufacturer proposing to submit a piece of machinery on trial, acceptance or rejection at pleasure of buyer
48 Letter claiming loss of shipment
49 Letter claiming damage or overcharge on shipment
50 An original series of letters, not less than six in number, similar in general plan to the series of letters printed as specimens on pages 204 to 211.

CHAPTER 5

Report Writing

THE REPORT is peculiarly the instrument of the engineer and the scientist. The writing of reports is an important part of the work of engineering students and of most practicing engineers. In college, students are asked to write papers on laboratory experiments and on visits to manufacturing plants. Immediately upon graduation, engineers are often required to write them, either for practice in a training course or in connection with a subordinate position in engineering work. In actual practice, engineers are called on to write reports of tests, reports on the progress of construction, routine reports of information, and longer recommendation reports on projects which may involve years of labor and large expenditure of money.

The advancement of an engineer in his profession often depends on his ability to present good reports. The executive in a big organization may know his men only through that medium. This does not mean, of course, that reports are an end in themselves or that they can have value if they are not backed by adequate professional knowledge. But it does mean that, other things being equal, a good reputation as a report writer strongly improves an engineer's chance of recognition and advancement.[1]

[1] The following comments from men in the industrial field indicate the importance that manufacturing companies place on report writing in the training of their young engineers:

"Each new college graduate is required to write a one-page progress report each week. This report is limited to one page, may consist of one paragraph, and the perfect report would contain only one short sentence. These reports are read each week by our manufacturing executives. . . . New college men are also asked to write long technical reports. These are always approved by a superior, not for the technical information contained but for form and clarity. . . ."—David M. Watt, Head of Employment Department, Industrial Relations Division, The Proctor and Gamble Company.

"Our reports [as a part of training procedure] go through the chain of command in the Engineering Department to and including the Vice-President of Engineering. Perhaps fifty men read these reports—and they read *every* report. These men (a) form an impression of the caliber of the author of the report long before they learn to know him personally as an individual, and (b) are the same men who pass on the merit ratings, promotions, and pay increases. . . . During our training program, we grade all examinations and inspection trip reports critically for English as well as for content."—B. H. Saltzer, Supervisor Educational Division, Wright Aeronautical Corporation.

The art of report writing, like the art of all writing, concerns itself with two things: ideas and style. The present chapter will first describe the technic of organizing and presenting ideas in report form; it will then describe the characteristics of the several types of engineering reports. The making of a written report involves four main steps:

1 Preliminary analysis
2 Assembling of data
3 Organization of data
4 Writing of report

The fact that three of these steps are prior to the actual writing is an accurate indication of the relative importance of preparation and execution. A satisfactory report is based on exhaustive forethought and study. The preparatory steps represent at least three fourths of the job. If the writer thoroughly understands his problem in advance, the actual writing of the report will almost take care of itself.

The executive who reviews all the reports received in the office of one of the largest engineering concerns in the United States stresses this advice above all other: "First the engineer must have his problem clear in his own mind. Then he must state his problem clearly. The better the English the better the report. Those men in our organization who put their reports in the clearest English have thought through their problems the best." Failure to conform at all times to this important principle will result in difficult writing, fumbled and incomplete data, incorrect statements, and unreliable conclusions. It pays to spend plenty of time in thorough preparation of material.

Preliminary Analysis

The first step in preparing to write a report is to ask yourself, "Exactly what is required of me? What facts am I expected to furnish? What problem am I expected to solve?" In other words, what is the purpose of the proposed report? Ordinarily this question will already have been answered by the client or superior who ordered the report, and it is essential to get his point of view at the outset; but it is helpful to re-formulate the purpose of the report in your own words and write it down. Then you are ready to ask yourself, "What are the chief component parts of the problem?" This may prove a harder

question to answer, unless you have had previous experience with similar work. Failing such experience you should not hesitate to ask for advice from colleagues, and you may also gain assistance from works of reference. Wherever you turn, you should strive to see your objective as distinctly and as completely as may be possible at this initial stage. The more specific the terms in which you formulate the purpose or purposes to be served by the report, the easier the subsequent work of investigation and the better the unity of the report.

The next step is to determine the scope of the study. Scope must not be confused with purpose. The purpose of a report defines the goal to be attained; the scope of a report determines the boundaries of the ground to be covered. Scope governs the degree of elaborateness to be adopted and the consequent scale of the report; it also acts negatively by ruling out irrelevant items. In other words, scope answers the questions of what shall be put in and what shall be left out. The scope of a report may be roughly indicated by the client, but must usually be left to the ultimate judgment of the engineer, who has the advantages of training, experience, and first-hand contact with the facts.

Having in mind both the purpose and the scope of the prospective report, you should now think the subject over both to clarify whatever ideas you have about it and to block out, however tentatively, some general plan of procedure to be followed in attacking the problem. Do not be in a hurry to get to the next stage. Take time to think over all the possibilities. You have already analyzed the problem into its chief components. Now, which of these are fundamental, which are secondary? Which questions logically come first, which next? Obviously time will be saved by clearing away the larger, underlying questions first, instead of groping among subordinate details. Here again, unless the report is to be a simple one, you must be guided largely by past experience, your own or others'. Some reports have a form as strictly standardized as a chemical formula; in such cases reference to the outlines of previous reports will suggest the plan of procedure to be adopted. If, however, the problem is a novel one, you may have to feel your way at first; but as the facts accumulate, you will seek to arrange them in logical order as rapidly as possible. Remember that no part of the preliminary analysis—statement of purpose, scope, plan

of procedure—is necessarily final. In the course of the investigation you must always expect the unexpected, and when it arrives, trim your sails and change your course accordingly. Adaptability and flexibility are quite as important as speed and decisiveness.

Assembling of Data

The work of assembling data will, of course, vary with the type of report. It we assume that the report is to be of some complexity, the assembling of data will consist of office and library study, and field investigation. First of all, examine all available sources of information which have a bearing on the problem. If you are connected with a large manufacturing or consulting firm, consult the files of your organization. Many engineering firms specialize in some particular field of construction or operation; their files contain abundant and pertinent data. The larger firms also maintain libraries of reference works and technical periodicals. Public libraries in the larger cities devote special departments to the literature of science, industry, and business. The libraries of technical schools afford a further source of reference material. But all this material is relatively inaccessible unless one has learned to make the fullest use of catalogs, bibliographies, indexes, and the like. If the subject under investigation is highly complicated and the scope of the report unusually comprehensive, it may be desirable to make a bibliography of the books and articles bearing on the subject. Ordinarily, however, it is sufficient to bring together the material which must be studied and then set about note taking. Notes should be concise, yet complete enough to embody all information needed for the final write-up of the report. Facts and figures must be copied with unerring accuracy. For a fuller treatment of note-taking, see pages 20 to 23.

So far we have been dealing with office and library studies. As soon as the findings of previous investigators are pretty well exhausted, it is time to do some exploring on your own account. This is called field investigation. If the problem is of a tangible nature, you may choose as the next step to make a bird's-eye survey of the physical situation. For example, the question of a dam location would call for an early visit to proposed sites merely for the sake of orientation. Subsequent visits will add their supply of detailed impressions, but the first visit affords a

rough introduction to the problem as a whole. In addition to actual observation in the field (and this may include visits to similar projects already in operation), the investigator makes use of interviews and their written equivalent, the questionnaire. It is not the purpose of this book to go into the technic of investigation, since that is a matter of engineering rather than of English. In some degree, too, it is a matter of tact, ingenuity, courtesy, and judgment. The art of questioning busy executives about their business can be gained only through experience, but ordinary good manners will carry one far. A single caution at this point: Don't accept statements without verifying them. Deliberate misstatement is rare, to be sure; careless or biased statement is common.

In drawing up a questionnaire, be brief. Omit every question that possibly can be sacrificed. Ask nothing for which you cannot reasonably expect an answer. Suit the form of the questionnaire to the convenience of the person addressed. The simpler the questionnaire, the larger the percentage of replies which may be expected.

Organization of Data

If we may assume now that the collection of information is completed, the time has arrived to bring order out of chaos. For chaotic the data probably are, however methodically they may have been collected. So far there has been no thought of the relative importance of data: one fact has received much the same attention as another. In the organizing of data, a sense of relative values is fundamental. What facts are significant? What facts are the most significant? What *is* their significance?

Rejecting the insignificant is something like thinning a garden. It is a painful business to pull up strong and shapely plants whose only fault is that there are too many of them. Similarly, it is not easy to lay aside facts and statistics which have been laboriously obtained, simply because they obscure the view of still more important matters. But unless the thinning is done remorselessly, the client for whom the report is written will not be able to understand it clearly. Keep in mind the requirements of the prospective reader; nine times out of ten he is not interested in details at all. His whole interest in the problem which you have so thoroughly studied may, perhaps, be summed up in four words: "Yes? No? How much?" It is

unlikely that you will need to use all your data to answer those simple questions. Yet the data, verified and filed, are available to support your findings if questions should arise.

Arrange the facts coherently and in order of significance. Here is, perhaps, the crux of the whole process of preparing a report. Here, for the first time, the fragments begin to fall into their places, the picture begins to assume form. It is impossible to offer a plan which will fit all the many different types of reports. Some of these types are described and illustrated in the latter part of this chapter. Only careful study of the strategy used in them will make clear the meaning of organization. But the matter is not so complicated as it seems. After all, you will be guided here, again, by the point of view of the reader. What does he want to know, and how can it be presented for his readiest and clearest understanding? An important firm of consulting engineers sums up the whole theory of report making in the following instructions:

> When our clients employ us to make investigations, no matter of what sort or extent, they do so largely to economize their own time. They also recognize the technical skill and standing of our organization. Such being the case, they have a right to expect that we will
>
> 1 Ascertain the necessary facts.
> 2 Digest these facts and draw the correct conclusions. The correct conclusions are the ones which are sound from a business standpoint as well as from an engineering standpoint.
> 3 Present these conclusions so clearly and concisely that they can be grasped without effort or delay.

The third of the foregoing requirements, that of a clear and concise setting forth of conclusions, may be satisfied most effectively by the making of an outline. Some experienced report writers are accustomed to working without making a preliminary outline in writing. But for beginners it is certainly inadvisable to write any but a rudimentary report without at least a mental outline. The novice had much better put his outline into writing, even though he chooses to work from it in its rough state. If the outline is not to appear in the report as a table of contents or as paragraph headings, it is needless to polish it beyond actual working requirements. But the value of careful, thorough outlining is not to be denied, even if you chance to be one of those

lucky mortals whose mind is a "clear, cold logic engine" capable of grasping and carrying a problem as a whole.[2]

The following outline of a report on prospective power market and plant development is rough but sufficient.

I Present system
  A Existing power stations
  B Type of line construction
  C Substations
II Interconnections
III Prospective business
  A Power
  B Lighting
IV Future power supply
  A Proposed power-station site
  B Proposed power station
  C Transmission system
V Probable cost of energy
  A Estimated sales in kilowatt-hours
  B Estimated generating costs
  C Total cost of energy
VI Conclusions and recommendations
VII Exhibits

There follow two specimen outlines of different kinds of reports. They will merely suggest to the report writer various ways of handling his material.

1

INVESTIGATION OF BEARING FRICTION

I Statement of the problem
II Experimental procedure
III Results and discussion
  A Effect of oiliness
  B Bearing metals
  C Clearance
  D Bearing length
  E Oil grooves
  F Viscosity
  G Load
IV Conclusions
V Recommendations for future work
Bibliography

[2] On outlines, see also pp. 23 to 27.

2

EFFECT OF CRANKCASE DILUTION ON RATE OF WEAR

Introduction
Résumé of the literature on dilution
Present experimental procedure
  Method of sampling
  Dynamometer tests
  Laboratory procedure
Treatment of data
  Road tests
  Dynamometer tests
Results
Discussion of results
  Factors influencing dilution
  Temperature
  Manifold design
  Fit of piston rings
  Average length of run
  Effect of dilution on the static coefficient of friction of the oil
  Effect of dilution on wear
Conclusions
Recommendations
Appendix
  Sample calculations
  Constants of the oil used
  Equipment and characteristics of cars used
  Bibliography

Writing the Report

Thus far we have been dwelling on the main discussion or body of the report, since this is the only part which naturally calls for an outline. The body of the report may be and usually is supplemented by other parts, such as the letter of transmittal, summary, and appendix, which are derived from the material embodied in the main discussion. The body, then, is actually written first, but we shall take up the writing of the several parts in their final order.

The following list contains all the elements which are ordinarily found in a report. Only the longest and most elaborate reports will include all of these elements.

1. Title Page
2. Table of Contents
3. Letter of Transmittal
4. Summary
    - Abstract
    - Conclusions
    - Recommendations

- Body
    - History of the Subject
    - Nature of the Study
    - Conclusions
    - Recommendations
- Appendix

Title page. The title page presents no difficulties. Its object is to state briefly but completely the subject of the report, the name of the organization or person for whom the report is made, the name of the engineer or firm submitting the report, and the date. Two specimen title pages are illustrated, the first in typescript, the second in print.

1

Report on

Knitting Mill Location

for

Clotho Knitting Company

Manlius, Mass.

Made by

Todd, Franklin & Company

Engineers

Job No. 2167 June 5, 1942

2

REPORT ON

Physical Condition and

Carrying Capacity of the

HARROW RIVER BRIDGE

at GRIERSON, N. Y.

Made for the

ALBANY AND NORTHERN RAILROAD

E. J. DUDLEY & COMPANY

Consulting Engineers *January, 1943*

Table of contents. The table of contents lists, in the order in which they appear, the several divisions and subdivisions of the report. It may be nothing more than the main headings, roughly equivalent to the chapter headings of a book. If the report is more complicated, the table of contents should be made up in analytical form. In either case, the outline already adopted can be closely followed.

Letter of transmittal or Foreword. The purpose of the letter of transmittal or of the more impersonal foreword is to introduce the report to the reader. To this end some or all of the following items will be used.

AUTHORIZATION. As a matter of record, it may be desirable to make some reference to the original order for the investigation. The official relationship of the report writer to the reader of the report may be mentioned.

PURPOSE. The object of the report should be clearly and briefly stated. It may be a restatement of the terms of the original commission, either verbatim or as understood by the writer of the report. Hence it is sometimes combined with the authorization. Any fundamental premises which have been assumed may be reviewed at this point.

SCOPE. The degree of comprehensiveness aimed at may be stated both positively and negatively; that is, what main considerations have been included and what have been excluded.

ACKNOWLEDGMENTS. The personnel engaged in the investigation, together with their duties, may be listed. Assistance from co-operating agencies and parties should be courteously but not effusively acknowledged.

Summary. The summary is the most important division of the entire report, inasmuch as it may be the only section to be read by a busy client. Although it is based upon the body of the report and is usually written after the body is completed, it is placed first in order to save the reader the necessity of traveling through masses of technical data in search for the answers to his questions. Putting the summary before the text is analogous to the newspaper practice of beginning every news story of any length with a short synopsis. The summary is an accommodation to the reader whose time is limited. It has no regular form. Essentially, however, it comprises three items:

ABSTRACT. The entire report is boiled down to the smallest compass compatible with clearness and completeness. Merely the gist of the investigation is given: an explanation of the nature of the problem and an account of the course pursued in studying it.

CONCLUSIONS. The findings or results of the investigation are presented in the order of their importance, the most important first. Remember that conclusions must be drawn from unquestionable premises and based upon adequate data, and that they must agree in every respect with the details presented in the subsequent pages. Inconsistency will cast a shadow of distrust over the entire report.

RECOMMENDATIONS. Conclusions and recommendations sometimes come to the same thing; usually, however, conclusions as to the past and present of a situation can be presented separately from recommendations as to its future treatment. Some types of reports do not require the submission of recommendations. In other reports, the recommendations are largely composed of estimated costs and estimated savings. If costs are given, a total figure, including all overhead charges, is sufficient at this point. If alternate recommendations are made, a separate estimate should be attached to each. What items are included and what items are not included in the estimate should be definitely stated. Estimated savings, often combined with the corresponding estimates of cost, should be clearly marked as net or gross or as qualified in any other way.

Body. We have now reached the report proper. The body or text of the report includes everything that we have to say, and allows a reasonable amount of space for saying it. A full and detailed discussion of data is made available here in case it is needed to substantiate the summary. Whether or not there is a likelihood of its being read, it should be written quite as carefully as those parts of the report which are certain to be read.

ELEMENTS. It is impossible to give any but the most general advice at this point, if it is to be applicable to all the different types of reports. The special make-up of the several types will be described in the later pages of this chapter. All types, however, contain some or all of the following elements in the text:

History of the subject
Nature of the study
Reasons for conclusions and recommendations

History of the subject. In some cases it is desired to clear the ground at the outset by reviewing the past history of the subject. Perhaps previous researches have an important bearing

on the present study. Perhaps lessons are to be learned from the failures of earlier experimenters. Perhaps the project has been partly completed already. Perhaps extraordinary conditions enter into the situation which must be understood before the specific questions under discussion are approached. See, for example, the Summary of a Full Report, pp. 280 to 287.

Nature of the study. The reader of a report may place greater confidence in its conclusions if he knows how they were approached. Hence a brief and definite statement of the nature of the study is not out of place. The method of procedure is recounted in chronological order; apparatus, materials, set-up, and so forth, are described; the duties performed by the personnel are explained. All this is by way of preliminary layout—the strategy of the attack.

Reasons for conclusions and recommendations. The conclusions and recommendations are the very kernel of the report. Here is the ground from which spring the findings already set forth in the summary. Hence it is imperative that the evidence be so organized and presented that the reader can follow the thinking step by step to its outcome. He knows what is wanted, how much is wanted, and how it has been sought. Now he is to learn by what process of experiment or reasoning the results have been reached. Obviously this section is as difficult as it is crucial; but the difficulty is hardly more than a matter of clear expression if the outline has been properly made. The difficulties have already been thought through. Reference to the outline affords a comprehensive analysis of the whole problem: logical order, interdependence of parts, relative importance of parts, emphasis, sequence—everything appears in the outline. It only remains to translate topics into complete statements, to clothe the bare skeleton of ideas with the firm flesh of words and sentences.

STYLE QUALITIES. The qualities of style essential to a well-written report are no different from the qualities of style already described with some fullness in Chapters 1 and 4. When it is recalled that many short reports are submitted in the form of letters, it will be seen that what was said in Chapter 4 regarding correctness, clearness, conciseness, completeness, accuracy, courtesy, and character in engineering correspondence applies, in much the same degree, to engineering reports. Because of

the comparative impersonality of the report, the last two items are of much less importance in report writing than in letter writing. On the other hand, convenience must be more carefully regarded in the long report than in the short letter. Hence, for the purpose of viewing briefly the qualities expected in the body of a report, we may follow this list:

Correctness
Clearness
Conciseness
Completeness
Accuracy
Convenience

Correctness. Correctness in the formal report is attained chiefly by the proper handling of words, sentences, and paragraphs. These have already been discussed with some fullness in Chapter 2. As for the form of the text, one should follow the usual conventions for the preparation of manuscript.

Use white, unruled paper of good quality, 8½ by 11 inches in size.

Typewrite the report, preferably in black ink.

Make a carbon copy for filing. The filed copy saves embarrassment if the original is lost, and may be required for reference in connection with future correspondence.

Leave ample margins on all sides of the page. If the report is to be bound, the left-hand margin should be extra wide.

Number pages plainly.

Words must be correctly spelled, hyphenated, and abbreviated. Use only abbreviations which are readily recognized; when in doubt, write out the word. (See Chapter 3.)

Except in tabular statements, every sentence must be grammatically complete. (See page 56.)

Punctuate correctly, using no more marks of punctuation than are necessary. (See pages 56ff and 160.) Skip three spaces between sentences.

Indent paragraphs five spaces. If the typescript is single spaced, use double space between paragraphs.

Clearness. Clearness in the text depends, to a great extent, on clearness in the outline. And clearness in the outline depends, as we have seen, on clear thinking. If the preliminaries have been faithfully performed, the major difficulties have been

removed, and the rendering of outline into text is largely a matter of intelligent paragraphing, effective sentence structure, and appropriate wording.

1 Words. Use words that admit of a single meaning only. Avoid hazy, slangy, and colloquial expressions. Be dignified without being pompous. Don't go out of your way to use a technical term merely to make an impression when a simpler term is equally accurate. Phrase your ideas so that they cannot be misleading when removed from their context. Occasionally passages are lifted out of a report for quotation in promotion circulars. Such quotations must not be, intentionally or unintentionally, ambiguous. See also pages 123 to 124.

2 Sentences. Write short sentences, as a rule. See that each sentence contains but one complete thought, makes a single impression, presents an idea that the reader can take in at one moment of time. See also pages 56 to 74.

3 Paragraphs. Be sure that your paragraphs represent logical divisions of the subject matter. Always have a good reason for putting a sentence or a group of sentences into a particular section. Cultivate the sufficient use of connectives, such as *although, since*; connective adverbs, such as *however, nevertheless, moreover*; transitional phrases, such as *on the other hand, in the next place, in any event*; repetitions of important words or phrases; and any other devices which help to articulate successive sentences into firmly coherent paragraphs. See also pages 33 to 51.

4 Unification. Just as a good sentence or a good paragraph presents one and only one main thought, so any composition as a whole should be directed toward a single objective. One subject, one report is a good rule. This does not mean that several subjects may not be treated in a single report, but the relationship must be such as to make them serve one end.

5 Sequence. The relationship of the several divisions of the main subject will be clearer if transitional devices are provided to bring out their sequence. Words, phrases, sentences, and even whole paragraphs are used to bridge the gaps between one idea and the next.

6 Proportion. Reference to the predetermined scope of the report will help to decide the scale on which the text is to be written. Reference to the outline will show which ideas

are main ideas and therefore presumably entitled to the most space, which ideas are subordinate ideas and therefore to be treated with relative brevity. But of course it is quite possible that the most important idea may be a very simple one. In dealing with ideas there is no inevitable ratio between weight and bulk.

7 Adaptation. In the style of a report consider your reader—layman, executive, director, technical expert—and adjust yourself accordingly. Try to see the subject from your reader's point of view and with his limitations of knowledge. If he is a prospective investor, he probably knows nothing of the technical phases of the subject and cares less, but he is intensely interested in the financial side of it; give him what he wants to know, in his own "language." If he is a fellow engineer, you can take many points of knowledge for granted and can use, if necessary, a vocabulary more technical than the layman's.

Conciseness. It does no harm to write out the first draft of a report as fully as you please. By so doing you are sure to include everything which you wish to include. But the rough draft must then be subjected to pruning. Beware of ponderous introductions. Guard against repetitions of thought. Delete statements which are plainly not to the point. Scan every sentence for superfluous words. You will be surprised at the number of words and phrases which can be eliminated without weakening the clearness of the text. If a report can be boiled down to a letter, so much the better. A long and elaborate report is justified only in treating subjects of exceptional complexity. Even then, the complexity of the subject does not necessarily determine the length of the report: an actual report on fire brick runs to 65 pages with 51 plates; a certain preliminary report on the feasibility of a $2,000,000 irrigation project occupies three pages. Most firms prefer that all formulas and similar technical details be omitted from the body of a report. If questions arise, they can be answered by reference to the appendix or to the engineer's job book. The head of an office handling large numbers of important reports says, "We want our reports short, hard-boiled, hard-headed, definite."

Completeness. Refer to the original assignment and ask yourself whether your report covers every phase of every ques-

tion that should be answered. An incomplete report means that supplementary reports must be called for, with consequent annoyance and delay. Ask yourself, too, whether in your zeal for brevity you have short-circuited any ideas. It is bad economy to send an unintelligible telegram in ten words when twelve words would carry the message clearly and completely. Have you made sufficient allowance for your reader's lack of technical knowledge? Have you included as much of the evidence as is needed to support your findings? Estimates of cost will probably be scrutinized more closely than any other part of the report. Are they presented so completely as to include every contingency and alternative?

Accuracy. Accurate reporting depends on accurate note taking, and accurate note taking depends in turn on accurate observing. To an engineer, accuracy must be second nature. Yet the human element is so fallible that it is never safe to assume that a report is finished until every fact and figure has been checked. *Look over your report before you hand it in.* Not only technical data but spelling, punctuation, abbreviation, and other matters discussed under the heading of Correctness must be checked for accuracy and consistency. Neatness and accuracy go together. A neat report is likely to be an accurate report; a slovenly report is at least not above suspicion on the score of accuracy.

Convenience. Emphasize, by position or by single or double spacing or by typographical devices, the main features of the report. A proper layout of the report so displays the facts that they can be grasped by the reader with the least possible mental effort and delay. Your reader will appreciate your every effort to serve his convenience.

Use headings—center, marginal, and paragraph—which correspond to the topics of the analytical table of contents. Be consistent in a parallel use of headings for topics of parallel importance. Headings should be of uniform grammatical construction. If the manuscript is to be printed, use capitals, small capitals, italics, and bold face to bring out the several degrees of importance assigned to the headings. For directions to the printer, see pages 449 to 452. If desired, use letters and figures, consistently, to indicate the relation of parts, as in the outline.

Appendix. In the appendix are placed all data which cannot be worked into the body of the report without interrupting the thought or which are too technical. If the body is self-contained, the data in the appendix are merely for purposes of reference when questions arise. Sometimes, however, all drawings, tables, and other exhibits are placed in the appendix, which then becomes an integral part of the body of the report. The appendix is used for so many purposes that it is possible here merely to enumerate some of the data often to be found in it.

Graphs
Computations and data sheets
Tabulated statistics
Diagrams and drawings
Maps
Photographs and blueprints
Bibliography
Index

Mechanical aids. Of great service in most reports, whether reserved for the Appendix as just indicated or incorporated in the body of the report, are such aids to clearness as charts, graphs, diagrams, tables, statistics, and photographs. The scope of this book hardly allows even a cursory treatment of so important a subject. The reader is therefore referred to the two lists which follow, alphabetically arranged, the former consisting of complete books on the subjects involved, the latter of sections from books. These lists represent selected items only. Specialists in this large province will no doubt be justified in making certain additions or subtractions. For the student who desires a brief introduction to the whole subject, one or another of the treatments referred to in the second list is recommended.

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Types of Reports

In the foregoing pages we have been discussing the theory and practice of report writing in general. We now turn to the definite usages and requirements which apply to the writing of specific types. We shall distinguish two large divisions under which all reports may be classified: (1) reports which embody information concerning past performance and do not involve the discovery of new facts; (2) reports which present and interpret the results of an investigation undertaken for the purpose of discovering new facts. Reports of the first sort are called information reports; those of the second sort, examination reports.

The following types of reports will be defined, described, and illustrated:

- Information reports
  - Periodic reports
  - Progress reports
  - Special information reports
- Examination reports
  - Examination reports with recommendations
  - Examination reports without recommendations
  - Research reports

It may as well be admitted, at the outset, that there are no hard and fast demarcations between types of reports, and that one type often merges into another. The several types outlined in this chapter must be treated separately for convenience of definition, but in reality reports can scarcely be so neatly ticketed.

Information reports. Information reports are usually simpler than examination reports. Their preparation calls for no difficult explorations, no solution of baffling problems. Only the gathering of known facts is demanded. Nor is unusual skill required in the writing of information reports. If the accumulated facts are put together in an orderly and convenient manner, it is enough. Little analysis or interpretation and no conclusions or recommendations are involved. The information report is simply a survey of facts, of progress, of location, etc.

Periodic reports. In the case of the periodic report, the method of survey is more or less historical. The writer presents a record of activities over a definite period of time—a day, a week, a month, or even a year. Many firms provide printed forms for these regular reports; the employer's questions are to be answered briefly, accurately, and definitely. But responsibility need not stop at that. If you have intelligent suggestions to offer, you may be sure that they will be welcome, whether or not the form makes provision for "remarks." Look upon the periodic report as something more than a routine affair. Two or three clear, sensible, and suggestive reports from a wide-awake man will convince the chief engineer of the worth of his subordinate.

If forms are not furnished, present your items of information in logical order, compactly and conveniently. Devise a form suitable to your needs and use it consistently every day, week, or month. This form should be as simple as the nature of the required data affords; no introduction or other preliminaries and no conclusions are needed. In fact the report will usually be nothing more than a well-constructed letter. In style, this type of report may be less formal than longer and more impersonal types; but if the data in successive reports are later to be embodied in a report covering a longer period, the organization should be tight enough to insure that the facts can be readily found and co-ordinated when wanted. (See pages 242-250.)

Progress reports. Progress reports resemble periodic reports in two respects: they convey information as to past performance, and they may be required at fixed intervals of time. But they go farther than periodic reports in that they pertain to changing and advancing conditions, whereas periodic reports describe a more or less stable state of affairs. In other terms, the periodic report is static, the progress report is dynamic. The progress report is used for subjects which because of their incomplete nature do not permit complete treatment. It may describe the results achieved up to a certain point in an extended investigation or series of experiments. It may record the successive stages of a piece of construction work. It may recount, from time to time, the findings of a surveying expedition. In any event, it is always moving toward the completion of an assignment and contributing toward the results which will

be summed up in a final report at some future date. The report may be submitted according to prearranged intervals of time, stations or places visited, kinds of work performed. Photographs, sketch maps, and other exhibits are often used as graphic records of progress. Often a printed form is furnished for field use. (See pages 242-251.)

Special information reports. Special information reports are complete compilations of data. They are called for at any time when specific questions arise and are often preliminary to more exhaustive examination reports leading to action. They do not ordinarily call for either conclusions or recommendations. A simple survey of the facts available upon a given question is all that is required, and the task presents no peculiar difficulties. The special information report is likely to be longer and more elaborate than the periodic or the progress report, since it aims to present and explain a complete body of facts. It is based partly on the writer's experience, partly on office and library study of accessible sources of information. If it also embodies the findings of a field investigation, it borders upon the examination report. The special information report is, as a rule, descriptive in nature, and its style is impersonal. (See page 252.)

INFORMATION REPORTS

1

REPORT ON ACTIVITIES FOR ONE DAY

[A student report]

Rutgers University
New Brunswick, N. J.
February 24, 1942

From: R. D. McNett

To: J. M. Heinz, Technical Personnel Director
Babcock & Wilcox Company
85 Liberty Street
New York City

Subject: Résumé of Activities for Wednesday, February 18, 1942

MORNING

Alternating-Current Machines

Study of the various starting methods for small, single-phase motors occupied the greater portion of an hour. The class discussed the characteristic curves for the split-phase, capacitor, repulsion, and shading-coil methods of starting. The best basis for comparison was found to be that of the slip curve. After demonstrating the solution of a typical problem dealing with motor efficiency, the instructor dismissed the class.

Advanced Machine Design

The entire hour was spent in blackboard work on problems dealing with various types of linkages. These problems required design specifications for such linkages as turnbuckles, eye-and-clevis connectors, automotive tie-rods, and steam engine crank-arms. Internal stresses induced by direct tension, direct shear, torsion, and bending were considered in determining dimensions for these machine parts.

Advanced Military Science and Tactics

Beginning the study of the construction of shelters, fortifications, and camouflages, the class listened to a lecture by the instructor. The lecture was confined in scope to general definitions, necessary fortifications against various types of artillery fire, and selection of positions.

AFTERNOON

Mechanical Engineering Laboratory

The class spent three hours learning the details of construction of the Elesco Superheater and the methods of operating the 62.5-kilowatt Westinghouse turbine in conjunction with this superheating equipment. As the description of the superheater was given, the class made sketches showing the arrangement of the tubes, baffles, and steam passages within its outer frame. Other sketches were made of the visible supply and exhaust lines to and from the superheater. Step by step, the instructor started the equipment in operation until the entire system, consisting of a turbine, a condenser, an exciter, and a generator, was operating on steam from the fully-loaded superheater. The load on the generator was a large bank of heating coils arranged in such a way that the load could be varied.

[R. D. M.]

2
WEEKLY PROGRESS REPORT—DAY BY DAY
[A student report]

Newark, Delaware
March 6, 1941

Mr. W. Francis Lindell
University of Delaware
Newark, Delaware

Dear Sir:

I respectfully submit for your consideration the enclosed progress report on the installation of the recently purchased centrifugal fan in the Mechanical Engineering Laboratory, for the week ending February 28, 1941. This installation, dated February 7, 1941, is listed under order No. 338-D-22.

Very truly yours,

Edward Samuel, Jr.

Edward Samuel, Jr.
In Charge of Installation

PROGRESS REPORT ON

INSTALLATION OF CENTRIFUGAL FAN

Work Completed

During the week ending Friday, February 28, the centrifugal fan was installed in the Mechanical Engineering Laboratory. The fan base was constructed, the dynamometer was installed, the pulleys were assembled, the pulley belts were adjusted, and the driving motor was overhauled.

Monday, February 24

The driving motor of the Nash Centrifugal Pump Set was uncoupled from the water pump. The pump was removed to make room for the fan.
The fan base was laid out.

Labor: 1 Foreman, 8 hours
1 Mechanic, 4 hours
1 Helper, 4 hours

Tuesday, February 25

The angle-iron pieces, forming the base for the fan, were welded together. Slots were cut in the top of the base to allow for variations in pulley center distances.

Labor: 1 Foreman, 8 hours
1 Welder, 4 hours
1 Helper, 4 hours

Wednesday, February 26

The fan was mounted on the base.
The pulleys were placed on the shafts.
A core was made for the 20-inch pulley.

Labor: 1 Foreman, 8 hours
1 Mechanic, 8 hours
1 Helper, 8 hours

Thursday, February 27

The driving motor was overhauled. The commutator and the brushes were cleaned and adjusted.
The voltmeter and the ammeter were calibrated.

Labor: 1 Foreman, 8 hours
1 Electrician, 8 hours

Friday, February 28

The dynamometer was assembled and tested.
Preliminary tests were made to check the apparatus.

Labor: 1 Foreman, 8 hours
1 Mechanic, 4 hours
1 Helper, 4 hours

Work Unfinished

Although the air duct for the unit has been ordered from the Sheet Metal Contracting Company, Wilmington, Delaware, it has not been received. After it is received, it must be assembled. The manometers must be attached to it and calibrated.

Upon the completion of this work, the fan tests necessary to determine the rotor characteristics will be made.

[*E. S., Jr.*]

3

WEEKLY PROGRESS REPORT—ACCORDING TO DIVISIONS OF THE WORK

[A student report]

413 Groves Street
Bridgeton, N. J.
March 4, 1942

From: W. K. Ryan

To: James H. Hartman, Chief Engineer
Bessemer Diesel Engine Company
3413 Broad Street
Philadelphia, Pa.

Re: Test of the recently-installed Bessemer Diesel Engine at the Wyoming Flour Mill—Report for the week ending March 3, 1942.

Equipment

The following test equipment was received on February 25 by truck:

1 Weston 3-phase wattmeter
1 Weston alternating-current voltmeter
1 Weston alternating-current ammeter
1 Maihak high-speed engine indicator
1 revolution counter
1 dead-weight gage tester

Inspection and Calibration

The engine was thoroughly inspected, and no defects were found. The oil-lubricating system, the water-cooling system, and the fuel-oil system were tested for stoppages and leaks. The starting-air tank was inspected and pumped up to pressure. The pressure gages were calibrated by the dead-weight method. The electrical instruments on the control board were calibrated by comparing them with the standard instruments which I received. Calibration curves were drawn for each electrical instrument and for each pressure gage.

Bessemer Company
March 4, 1942
Page 2

Tests

One six-hour no-load test and four six-hour load tests were run. In all of these tests, the engine was operating under normal conditions for the particular load. The load tests were run with loads of 6, 15, 20, and 28 kw. Only one major difficulty was encountered in the operation of the engine. This was a stoppage in the fuel nozzle on No. 2 cylinder, which occurred during the 15-kw test. It was caused from dirt in the fuel. The test was discontinued, the fuel nozzle was cleaned out, and another 15-kw test started.

Recommendation

In order to overcome the difficulty caused by the stopping up of the nozzles because of dirt in the fuel oil, I recommend that a dirt filter, such as the Combustion Engineering Type 6-A-4, be installed just ahead of the main oil pump.

General

I talked with Mr. Fred Dolby, manager of the Wyoming Flour Mill, and he seemed well pleased with the performance of the unit as indicated by the tests thus far.

Very truly yours,

[*W. K. R.*]

4

FORM REPORT—WEEKLY PROGRESS REPORT OF ERECTION[3]

Date June 24, 1941

Customer Consolidated Electric Power Co. Location Haywood, N. C.

General Order No. SY-27894 Supervising Engineer Martin Woods

Apparatus: 2—40,000-kw Waterwheel Generators
S.O. 9D-786 Ser. No. 1S-9D-786, 2S-9D-786

3—33,333-kva Transformers 1 phase 110,000/33,000
OISC. A.B. Ser. No. 2,980,010-11

	ERECTION STARTED			ESTIMATED OR ACTUAL					
				Erection Completed			Operating Date		
	First Unit	Second Unit	Third Unit	First Unit	Second Unit	Third Unit	First Unit	Second Unit	Third Unit
Turbine									
Condenser									
Generator 2 W.W.	Mar. 15	Apr. 15		70%	30%		Aug. 1	Oct. 1	
Switchboard									
Auxiliaries									
Transformers 2	Apr. 20	May 20		80%	20%		June 15	July 15	

[3] Below printed forms such as this one there is additional space for a more detailed statement of the work completed.

5
PERIODIC PROGRESS REPORT

May 15, 1942

Mr. W. B. Furman, Engineering Department
XYZ Company
P. O. Box 450

Subject: Turret Motor Plant
Defense Plant Corporation
XYZ Company, Lessee
Monthly Progress Report

Dear Mr. Furman:

We are pleased to submit herewith a report of progress on the Turret Motor Plant as of April 30:

Engineering Progress

(a) 43 sets of specifications cover the job 100 per cent. They have all received your approval.

(b) 3 drawings covering Yard—general plot, fence, walkways, roadway, and railroad siding—are 100 per cent complete.

(c) 8 drawings covering Architectural Plans and Buildings—floor plans, architectural elevations and sizes, roof plans, miscellaneous details of wall sections and louvres, door and window schedules, pump and guard houses—are 100 per cent complete.

(d) 15 structural plans—drawings covering foundations, trusses, columns, miscellaneous iron, reinforced steel, water tank, reinforced concrete roofs and frame details, foundations for silos, coal handling, compressors, and fire pump—are 100 per cent complete.

(e) 4 electrical drawings—Electrical drawings are 99½ per cent complete. The incomplete drawings cover control circuits for coal stokers and for the fire pump. These are being held up due to lack of information from manufacturers of that equipment.

(f) 9 drawings covering Building Services—these drawings are 100 per cent complete.

2 Mr. W. B. Furman 5/15/42

Construction Progress

The following tabulation lists a description of work involved, percentage completion of each item as of April 30, and the actual and estimated completion date of each item:

Description	Percentage Completion	Actual or Est. Completion Date
Grading, Filling & Excavation	82	5/23/42
Railroad siding	0	6/8/42
Roadways & Parking Areas	18	6/8/42
Fence	5	5/31/42
Concrete Foundations	98	5/15/42
Structural Timber	100	3/31/42
Brick Walls	100	4/30/42
Sash and Doors	97	5/31/42
Roof and Roofing	98	4/30/42
Interior Partitions	55	5/31/42
Wood Block & Tile Floors	80	5/15/42
Concrete Floor	92	5/15/42
Sewers & Drains	82	4/30/42
Fire Prot. & Water Supply	72	6/30/42
Plumbing	60	6/15/42
Heating	50	6/15/42
Boilers & Stokers	0	5/15/42
Radial Brick Chimney	100	4/24/42
Coal Silos	10	6/30/42
Coal Conveyors	0	6/25/42
Air Compressors	20	7/30/42
Underground Water Tank	100	4/30/42
Electrical Substation	10	7/8/42
Power & Lighting	49	7/15/42
Painting	50	5/23/42

We believe that this gives you a picture of the progress of the job up to the end of April. If there should be any further information which you require, please do not hesitate to call on us.

Very truly yours,

Day & Zimmermann, Inc.

CC—Defense Plant Engineer
Job Book

6

SPECIAL FIELD REPORT

Date February 11, 1942

To Philadelphia Service Dept. Attention of F. S. North

G. O. No. RL-77619-R-7 Frame No. 204 Serial No. 2179634

Customer Apex Paper Co. Location Birchwood, Pa.

Apparatus Single Motor Paper Machine Drives S. O. No. 61-G-44
(Give complete nameplate rating)

Pilot regulator generator
½ kw 250 volts, 2 amp, 1750 rpm

Time in Service: Nine (9) months.

Complaint: For the past two months the customer has experienced trouble on account of variations in paper machine speed.

Conditions as Found: It was definitely ascertained that the condition was a result of commutation on the Pilot Regulator. Cleaning the Pilot Regulator commutator would cause a speed reduction of from 15 to 20 ft per minute.

Work Done: The armature was removed from the Pilot Regulator and the commutator refaced and undercut. New style brushes type BB were installed.

Conclusion: Attached Tachometer Charts show speed variations before and after installation of new style brushes. Expense to be charged to Field Development.

Material to be Ordered: None.

7

SPECIAL INFORMATION REPORT

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

2—SOUTH PHILADELPHIA

Date March 29, 1943

To St. Louis Engineering Dept. Attention of G. M. Nilsson

G. O. No. __________ Frame No. 16 B.C.W. Serial No. 1262

Customer Santa Fe R.R. Co. Location Argentine, Kansas

Apparatus 500-k.w. turbo generator S. O. No. __________

On last Wednesday, March 26, Mr. W. I. Coldwell of the Kansas City office called me regarding a visit to the above-named customer in connection with a survey to determine the spare parts which the customer might need for the unit. I arranged to report to Argentine on Friday, March 28, and met Mr. R. E. Rader, erecting foreman for the customer, from Topeka, Kansas.

The customer had the cylinder cover removed and turned over. The spindle had been removed and was cribbing on the plant floor. The steam chest and nozzle had been removed and the chest was open for inspection. The generator had not been dismantled, other than the bearing covers from the exciter.

Cylinder Cover—The reversing impulse blades were found excessively worn on the inlet edges and should be renewed. The reaction blading looked to be in good condition, except that the first 7 rows were excessively plugged with grease. The customer was advised to clean these blades before assembling.

Spindle—The main thrust bearing and the #1 bearing were found excessively coated with carbon and in need of cleaning. The #1 gland gunner was excessively plugged with scale and needs to be cleaned. The first row spindle impulse blades were found eroded approximately ¼" on the inlet edge and should be renewed. The #2 spindle impulse row blades are satisfactory. Four rows are cut off. The 5th to the 15th reaction rows in the spindle are plugged with grease and in need of cleaning.

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Santa Fe R. R. Co.

The #2 gland runner was also found excessively scaled and needs to be cleaned, as well as the spindle body.

Cylinder—The reaction blades were found excessively plugged with grease and need to be cleaned. This grease comes from the air compressors operating in the plant. The #2 gland seal case was found excessively eroded in the groove and should be renewed.

Mr. Rader remarked that he did not think the mixed pressure regulator was operating properly in that he was having trouble controlling the machine, and would like to have this repaired at the time the new parts are installed. For the present they expect to clean up the unit and put it back in service.

I found the oil-way through the exciter armature plugged with carbon from the oil, and instructed the customer to open this before resumption of service. The customer advised that he did not know that this opening through the shaft was for the purpose of lubrication.

I found the valves and valve bushings of the steam chest excessively worn. Also the governor speed changer worm and worm gear and stem were excessively worn.

The collector rings on the field are very rough and should be ground for truing at the time of doing the installation of these new parts.

Mr. Rader requested that our Kansas City office prepare an estimate on the price for the following parts to be furnished for this turbine, as well as the time required in order to make shipment, and forward this information to Mr. B. P. Phelps, Engineer, Shop Extension, Room 43, Motive Power Building, Topeka, Kansas (Santa Fe R.R. Co.):

Blading, material, and necessary tools to install first row spindle impulse blades.
Blading, material, and necessary tools to install reversing impulse blades.

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	Item No.	Supp.
1—Gland case complete with inner seal ring and bolts for the coupling end of the turbine	2-3-31 & 32	23
1—Primary valve bushing (upper)	80	7
1— " " " (lower)	81	7
1—Secondary valve bushing (upper)	82	7
1— " " " (lower)	83	7
1—Primary valve	71	7
1—Secondary valve	72	7
1—Primary valve stem	110	7
1—Secondary valve stem	110	7
1—Primary valve bonnet bushing (upper)	77	7
1— " " " " (lower)	78	7
1—Secondary " " " (upper)	77	7
1— " " " " (lower)	78	7
1—Governor speed changer (main bushing)	14	13
1— " " " (spindle)	22	13
1— " " " (worm)	35	13
1— " " " (worm wheel)		13

This estimate should include time and expense of the engineer to supervise the installation of these parts and the time and expense for the blader.

On completion of my inspection at this plant I returned to the Kansas City Power and Light Company plant.

JHR:me

J. H. Rathmell

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SURVEY AND SALES LETTER REPORT

May 27, 1942

Gentlemen:

In accordance with your request, we have made a survey of the emergency service requirements of the ———— Hospital.

Service from the ———— Electric Company system now is being supplied for emergency lighting only in the Admission Bldg., Chapel, Employees' Building, and Power Plant. The total demand contracted for is 25 kw and the annual minimum is $744. Extension of this service to Buildings 13, 14, and 50, which you have requested, would increase the demand to 36 kw and the annual minimum to $1039.68.

In making this survey, we have considered also the extension of emergency electric service to include other apparent needs and the most advantageous method of supplying these needs. We feel that it would be of vital importance to have available, from an outside source, capacity to operate the boiler feed pump and forced draft fan. For example, during the recent coal shortage, had the situation become so acute that you would have been unable to maintain steam pressure, resulting in a complete shutdown of your power plant, it would have been impossible to start the plant again without an independent source of power for this equipment. The capacity required for emergency service for this equipment, together with the emergency lighting previously mentioned, would be 111 kw, with an annual minimum charge of $3055.68.

Emergency service should be extended still further to include No. 10 well pump, which then would be available for water supply and, even more important, for fire protection service. The total capacity required then would be approximately 126 kw, with an annual minimum charge of $3458.88.

A summary of these items is as follows:

Item	Dem. Kw	Minimum Kwhr/Mo.	Annual Minimum Charge
1—Present Service	25	1250	$ 744.00
2—Present service and emergency service to Bldgs. No. 13, 14, and 50	36	1800	1039.68

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3—Item (2) and boiler feed pump and forced draft fan	111	5500	3055.68
4—Item (3) and No. 10 well pump as a fire pump	126	6300	3458.88

In reviewing the operating conditions and power requirements of the institution as a whole, consideration was given to the establishment of an electric installation which would make emergency service available to many more of the important functions of the institution, provide reserve power and reduce generated power during periods when the need for exhaust steam is curtailed and the excess exhaust steam is wasted.

During the past winter, there were periods during which the electrical requirements of the institution exceeded the rated capacity of one generator. With the addition of Building No. 50, the electrical requirements next winter probably will exceed the capacity of one turbine materially, making necessary the operation of both generators to carry the load. This would eliminate the reserve capacity which you have now, leaving no other source of power available should one generator fail.

There is available in the institution a bank of transformers and oil circuit breakers which, with some rearrangement and reconnection, together with the installation of some additional equipment at the present switchboard, would provide an electric service installation of 300 kva. This could be used to improve the economy of operation of the power plant and to provide reserve capacity to take care of emergency requirements, with limitations, on any and all of the outgoing distribution circuits from your plant. Details of the suggested changes are attached to this letter. It has been estimated that the probable cost of this installation would not exceed $4000. These details and the cost of installation are subject to confirmation by your engineers.

In considering the supply of the future power requirements of the institution with this electric connection available, we determine that your circuit LDY, which now serves the farm, laundry, reservoir, and which will serve Building No. 50 in the future, could be operated normally from ———— Electric Co. service. This would carry the load in excess of the capacity of one generator, enabling you to hold the other generator in reserve to protect against failure of the generator in operation. During periods when exhaust steam requirements are reduced, this would eliminate a portion of the exhaust steam now being wasted.

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Service for this installation would be billed under our Rate ——. We would agree to supply a maximum capacity of 300 kva, which under this rate requires a minimum of 200 kw. The annual minimum charge with this arrangement would be $6000, which includes the minimum demand of 200 kw and the use of 20,000 kw-hr a month. Our estimate of the power requirements of circuit LDY, including Building No. 50 is 107 kw-demand and 58,550 kwhr per month. The annual cost of this service is $8895.60, which exceeds and utilizes the minimum guarantee and charges of the rate. The additional capacity available in the suggested minimum of 200 kw would supply emergency service for practically all of the requirements outlined under item 4. In addition, we have estimated that the reduction in fuel cost caused by the reduction in wasted exhaust steam would be $3732.56. No estimate of decrease in cost of power plant maintenance and supplies due to this reduction has been made.

The statements discussed above are summarized as follows:

Total annual cost of power requirements of circuit LDY		$8895.60
Emergency service for lighting, boiler feed pump, forced draft fan, and # 10 well pump (Item 4)	3458.88	
Reduction in fuel cost	3732.56	
		7191.44
Net annual cost of service for circuit LDY 58,500 kwhr x 12 mo.—702,600 kwhr per yr.		$1704.16

From the viewpoint of availability of reserve and emergency capacity, flexibility and economy of operation, and the provision of reserve capacity at low cost, this installation has many advantages to recommend it.

I shall be glad to call to discuss it in detail at your convenience.

Very truly yours,

Director, Industrial Sales
Suburban Divisions

Examination reports. Examination reports are reports of all sorts which require the investigation of the unknown. The purpose of the investigation is to obtain and interpret facts about manufacturing plants, machinery, processes, institutions, organizations. The reports may deal with inspections, experiments, surveys, analyses. The investigator relies upon (1) his own experiences, (2) reading in connection with the particular assignment, (3) examination and study of the special problem or conditions involved, (4) interviews with persons who can speak authoritatively on the subject, and (5) perhaps questionnaires.

Everything that has been said in the earlier pages of this chapter regarding the technic of investigation, organization, and preparation of reports applies, with particular force, to the writing of examination reports. The directions already given on pages 222 to 228 are, then, assumed as part of the following discussion, and the student is advised to be thoroughly familiar with them before going further with this study.

Examination reports with recommendations. By far the greater number of examination reports are written to serve as a basis for decision and action. The expert opinion of the report writer is therefore required in the form of recommendations, and these recommendations are the distinguishing feature of the report. Although they may actually appear in the summary at the beginning of the report, they have been reached only through the whole course of investigation and conclusion, described in the body of the report. It is important, then, that the whole report should be so put together as to contribute to the single end of giving weight to the recommendations. There are as many ways of doing this as there are kinds of subjects to report upon. In general, however, the strategy of the report writer is to lead his reader from a preliminary statement of the problem, through the successive stages of investigation into present conditions, until he is ready to listen to the writer's recommendations as to the future. In outline form, using only the most general of terms, the layout of the examination report is something like this:

I Background of the report
- A Definition of the problem
- B History of the subject

C Prior researches in the subject
II Present status
A Preliminary survey
B Main investigation
1 Interviews and questionnaires
2 Experiments and sampling
3 Tests and calculations
C Analysis of findings
III Future probabilities
A Conclusions
B Recommendations

On the responsibility, practicability, and good judgment of your recommendations rests your reputation as an engineer. See to it that you do yourself justice by phrasing your ideas definitely and conclusively. You have been hired to settle a question. Unless the question is insoluble, you cannot hedge on the answer.

EXAMINATION REPORTS WITH RECOMMENDATIONS

1

INSPECTION OF A UNIT

[A student theme]

1904 Scott Street
Marcus Hook, Pa.
March 20, 1942

The Jessup and Moore Paper Company
Philadelphia, Pennsylvania

Attention: Mr. J. G. Ramsey

Gentlemen:

In accordance with your letter of instructions of March 3, 1942, I have made a personal inspection of all the electrical equipment of your Augustine Plant and submit the following report.

Power Supply

Transformers The three step-down transformers that deliver power to the plant are in fine operating condition. They are, however, in need of a protecting coat of paint.

Control Equipment All control equipment is in good condition with the exception of the disconnect-switches on the high-tension side of the transformer bank. These switches, it seems, have not been operated for some time and are badly corroded.

Main Machine Room

Paper Machines The synchronous motors which drive the drying rolls are in excellent condition. The motors driving the rack and suction rolls at the wet end of the machines are covered with pulp and debris, and those of No. 2 machine are in poor operating condition. This condition should be remedied if these motors are to continue in their operation.

Calenders All motors supplying power to the calenders are in fair condition and need no attention.

Pulp Room

Most of the electrical equipment in the Pulp Room is obsolete and in bad condition. However, since you plan to reconstruct this department, the condition will be removed.

Digesters and Beaters The driving motors of all three digesters are in very poor condition as are the motors on the beaters. Before you can operate at an economical efficiency these motors will have to be replaced.

Conveyors The motors driving the two belt conveyors operate in a dust-laden atmosphere. To prevent dust explosions, these motors should be replaced by explosion proof motors.

Control Equipment All control devices of this department are obsolete. They should be replaced when the department is remodeled.

Cutting Room

Since this department was only recently remodeled the electrical equipment is still in good condition and needs no attention.

Machine Shop

All motors and control equipment in the Machine Shop are in good operating condition but are poorly maintained. All electrical equipment should be cleaned and painted.

Box Factory

All electrical equipment of this department is in good condition. However, the motor driving the band saw in the south end of the building is overloaded and may cause trouble

if heavy work has to be done. I suggest that this motor be replaced by a 5-HP squirrel-cage induction motor. The present driving motor may temporarily replace one of those in the Pulp Room.

Loading Shed

All freight-handling equipment, including electric trucks and battery-charging sets, is in good condition.

General Remarks

The illumination in some parts of the plant is poor. The lighting system of the entire plant, particularly that of the Pulp Room and Cutting Room, should be inspected by an illumination engineer.

Recommendations

It is recommended:

1 That the disconnect switches on the high-tension side of the transformer bank be cleaned or, if necessary, replaced.

2 That the power transformers be painted. Because of its excellent heat-conducting properties, I suggest for this purpose the use of Alco-Aluminum Paint.

3 That all motors operating the wet end of the paper machines be replaced by totally-enclosed splash-proof motors.

4 That all motors operating in the Pulp Room be replaced if the reconstruction of this department is not completed within one year.

5 That the motors driving the pulp conveyors be replaced by explosion-proof motors.

6 That all motors in the Conveyor Room be equipped with oil-circuit breakers.

7 That all electrical equipment in the Machine Shop be cleaned and painted.

8 That the motor driving the band saw in the Box Factory be replaced by a 5-HP squirrel-cage induction motor.

9 That the entire lighting system be inspected by an illumination engineer.

Very truly yours,

H. W. Corman

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BRIEF REPORT ON SITE FOR PLANT

[A student theme]

1408 Burton Street
Chester, Pa.
March 27, 1942

To: Robert O. Johnson, President
American Heating Supply Company
Wilmington, Delaware

From: John Vaklyes, Jr., Consulting Engineer

Subject: Suitability of plot of ground at Ninth Street and the Baltimore and Ohio Railroad for construction of plant for manufacturing heating equipment.

Location

The site considered for the establishment of your plant is at the junction of the Baltimore and Ohio Railroad's main line and two main highway trunk lines. It is in a district served both by trolley coach and bus service lines. The plant would be on the edge of a Class A residential district, but your manufacturing processes should be unobjectionable to the residents of that section. A railroad siding already constructed would serve the plant, and trucking facilities could easily be arranged.

Description

The property consists of 3.4 acres of cleared ground laid out in a triangular form, the hypotenuse of the triangle being along the railroad. The base of the triangle, or north side of the plot, is adjacent to the property of a leather-processing plant. The remaining side runs parallel to Bancroft Parkway, west of the area. The Parkway side is sunken below the street

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level from four to eight feet, and the side bounded by the railroad is about 15 feet above the road-bed level. The ground slopes very gently from the street to the railroad. The only obstructions on the grounds are small trees planted about 30 feet apart along the street side of the area. These may easily be removed if they impede construction.

Soil and Drainage

Tests show the soil to be a thick layer of rich loam supported by a solid clay base. The slope of the ground permits rapid run-off of rain water during storms. There is no danger of flooding. Excavations can easily be small since no rock would be encountered within a reasonable depth.

Utilities and Protection

An ample supply of pure water at a pressure of 60 psi is available from the city water system. Electric power up to 2300 volts can be readily obtained. Illuminating-gas mains and sanitary-sewage pipes may be tapped for service when necessary. The district is very well protected by the efficient police and fire departments of Wilmington.

Recommendations

This site satisfies all the requirements of a manufacturing business such as yours. I feel that it would be to your advantage to construct your proposed plant on this property, especially since there is no other property of like size better suited to your purposes in the city of Wilmington.

[J. V., Jr.]

3

FULL REPORT ON EXPANSION

REPORT

ON

EXPANSION OF ARTIFICIAL LEATHER DEPARTMENT

FOR

A CLIENT[4]

JANUARY, 1941

[4] Report supplied by Lockwood Greene Engineers, Inc.

Report

on

Expansion of Artificial Leather Department

OBJECT OF REPORT

The object of this report is to study methods of providing additional floor space for the expansion of the Artificial Leather Department, to make comparative estimates of cost for various solutions, to discuss the advantages and disadvantages of various schemes, and to make recommendations.

HANDICAPS OF PRESENT SPACE

The present space occupied by artificial leather manufacturing is badly crowded. This applies not only to the dope mixing department, but also to the balance of operations including raw cloth storage, cloth preparation, coating, embossing, inspection, finished goods storage, and packing.

The floor space now occupied on the ground floor of the one-story building on the west side of Jefferson Street is approximately 42,000 square feet, and in addition a small amount of space is occupied at the second floor level in the dope mixing department.

These figures are exclusive of the solvent recovery plant, which forms an essential part of this process and which represents a large investment. This solvent recovery system is located centrally in relation to the coating machines, and the cost of moving this recovery system, as well as all of the coating machines, would be so high that it cannot be considered.

REQUIREMENTS FOR ADDITIONAL SPACE

This department requires for immediate needs approximately 10,000 square feet on the ground floor and some additional space on the second floor for dope mixing.

In order to take care of future and longer term needs, any solution should provide a method for getting about 20,000 square feet of additional space closely adjoining the present coating department.

At the present time this whole department is a one-story layout, with the exception of some overhead tanks in dope mixing. It would not be feasible to rebuild the present one-

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story building into a multiple-story building while continuing to carry on manufacturing operations, since any new building for this purpose would have to be a heavy building of fireproof construction and would probably require pile foundations. This would mean a major rebuilding operation, and the cost would not be justified by any space requirements which now exist.

It is felt that any space for production requirements now in view for manufacturing operations should remain a one-story layout, with final dope mixing, coating, embossing calenders, and embossing presses all on the ground floor, and that while it would be desirable to have other operations also on the ground floor, it would be possible, if sufficient ground floor space is not available, to have on upper floors with good elevator service the storage and preparation of raw cloth ahead of coating, the inspection and cutting of finished product, the open stock storage, packing room, and all operations up to the actual loading of cases, which could be done at the ground floor level.

LAND AVAILABLE FOR EXPANSION OF THE DEPARTMENT

No vacant land is available north of the present buildings on the Jefferson Street frontage, and it is understood that it is practically out of the question to buy any ground at this point.

Some ground is available along the west side of the building and located both north and south from the solvent recovery plant and extending through to Desplaines Street as shown by the print bound herewith.

METHODS SUGGESTED FOR PROVIDING ADDITIONAL SPACE

Three possible methods of providing the additional space have been suggested and considered and will be discussed here as follows:

I Build a 40 ft by 111 ft wing, two stories high, west of present building for expansion of dope department, and a 60 ft by 111 ft wing, one story high, west of present building for expansion of manufacturing, neither of these buildings to be provided to carry any additional stories.

II Build a 40 ft by 111 ft wing, 2 stories in height, west of present building to expand dope department, and

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build a 60 ft by 111 ft one-story building west of present building to provide for expansion of manufacturing, this building to be provided with foundations, columns and roof slab suitable to take at least two additional stories in height to be added later. As a further alternative, the width of this building might be increased to 75 ft.

III Move the grey goods storage, singe room, and bleachery out of the present buildings at the south end of this block and into a new bleach house to be constructed east of the present finishing building so that space vacated can be made available for the artificial leather department.

DESCRIPTION AND ESTIMATED COST OF SCHEMES

SCHEME I

This would provide floor space, as follows:

2nd floor	4400 sq ft
1st floor	11,000 sq ft
Total Floor Space Added	15,400 sq ft

Estimated Cost for Scheme I . . . For the building construction, you have already obtained proposals from a contractor named ———— in Chicago, as follows:

For 2-story building exclusive of mechanical equipment, but including elevator	$31,881.
For 1-story building, exclusive of mechanical equipment	17,642.
In order to complete the estimate, we add:	
Allowance for wrecking buildings on site	1000.
Allowance for mechanical equipment of buildings; that is, plumbing, heating, sprinklers, lighting	8000.
Allowance for moving and relocating manufacturing equipment as follows:	
Allowance for moving of 15 embossing calenders and presses into one-story building	5000.
Allowance for moving and extending dope room equipment	3000.
Total to here	66,523.

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Add for Miscellaneous & Contingencies—10%	6652.
Total Estimated Cost for Scheme I	$73,175.

While the above figure is based on moving all of the embossing equipment, it is possible that in the beginning this one-story extension could be used mainly for the storage of cloth, and that much of the embossing equipment would remain as it is until further coating machines are required.

Advantage of Scheme I . . . The advantage of this scheme would be that it is probably the cheapest thing that could be done to provide some relief for this department. The land is already owned, the buildings on this land can be removed quickly, and new space could be made available in a very short time. Space gained is as close as possible to the departments where additional space is needed.

Disadvantage of Scheme I . . . The disadvantage of this scheme is that it may turn out to be a totally inadequate provision for future growth of this department. If the department continues to grow, it may be only a few years before the same problem would have to be met again with another solution since this plan would use up all of the available vacant land and there is no other ground immediately available for further extensions at the point where they are needed.

We might add that we have examined the drawing submitted by Mr. ——— for the proposed buildings, and that we have some question about the adequacy of the foundations provided by him in view of the very poor soil conditions encountered at the Finishing Building across the street. We would by all means recommend that before constructing any structures here borings should be taken to show the character of the soil, and the best possible advice should be secured on the foundation question to guard against serious settlement of buildings.

SCHEME II

This would locate wings on the west side of the building at exactly the same locations as in Scheme I, except that the one-story building proposed under Scheme I would be constructed with foundations, columns, and roof slab ready to be extended later to a height of at least three to four stories. This building when extended in height would have to be provided with two stairways, with a substantial freight elevator adjoining the west line of the present one-story building, and should be of fireproof construction. We believe it would be necessary to have this provided with pile foundations.

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In view of the fact that two stairways and an elevator would be required regardless of the size of floor space on one floor, we would like to see this building constructed to a width of 75 ft in place of 60 ft. The only drawback to this extra width is that it would infringe still further on the emergency coal storage space at the north end of the boiler room, cutting this from 46 ft, as left under Scheme I, to 31 ft. This might be considered allowable provided you could get some vacant ground across the street from your boiler house for a permanent coal storage. At the present time there are some rather old houses on this property, and they might be obtained cheaply.

Another alternative would be to provide an emergency coal storage on other vacant ground which you may own, located further away from the boiler plant; for instance, on vacant ground east of the present finishing building.

Floor space provided by this scheme, if maintaining the 60-ft width, would be as follows:

1st floor	11,000 sq ft
2nd floor	4400 sq ft
Total, to be added now	15,400 sq ft
Available for further expansion when needed would be space in 2 upper stories, or	13,000 sq ft
Total, with 2 stories added	28,600 sq ft
If the 60-ft width can be increased to 75 ft, then the above figures become	17,050 sq ft
and	31,900 sq ft

Estimated Cost for Scheme II . . . This estimated cost is made up as follows:

Estimated cost for new buildings, including plumbing, heating, sprinklers, lighting, and elevator in two-story building	$ 69,830.
Cost for wrecking old buildings	1000.
Cost to move manufacturing equipment	8000.
Total to here	$ 78,830.
Add 10% Contingencies	7880.
Total Estimated Cost for Scheme II	$ 86,710.

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This total would be slightly increased if the 60-ft width can be increased to 75 ft, in which case the increase for the one-story building would be about $6000, making the total $93,710.

Advantages of Scheme II . . . Advantages of this scheme are as follows:

Space can be made available quickly and is at the location where it will be most useful.

The cost is more than for Scheme I, but provision is made for future expansion of the department when required, by the use of an elevator and by transferring certain departments to upper floors when found necessary.

When the finished goods storage and packing and shipping are transferred to this building, shipments would be made from the west side on Desplaines Street.

A further feature which could be incorporated into this scheme would be to construct an overhead bridge across Jefferson Street from the northwest corner of the present Finishing Building, to leave that building at the roof level and to connect to a fourth story on this proposed new building, or to connect with an elevator on this building at the roof level.

Such a bridge would eliminate the necessity, which exists at present, of trucking all cloth out of doors to get to the Artificial Leather Department. With such a bridge, cloth could be taken up to the roof level of the Finishing Building in the north elevator of this building. A bridge could be constructed across the roof to the northwest corner, and from there to the proposed new building. The roof of the Finishing Building is approximately 40 ft above the first floor of the Artificial Leather Department. The bridge, therefore, run level, would land at about a fourth-floor level on the proposed new building.

Disadvantages of Scheme II . . . Disadvantages of this scheme would be that it costs somewhat more than Scheme I; it would eventually require the storage of cloth and finished goods at a level above the first floor and the continued use of an elevator for this department. This seems to be unavoidable as long as there is not sufficient ground space anywhere to get the required extension in the form of a one-story building.

SCHEME III

In Scheme III it is proposed to move the bleach house completely to a new location east of the present Finishing

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Building in order to gain the space now used in both first and second stories for the use of the Artificial Leather Department, and to set up a new bleachery conveniently located for pulling cloth direct from it into present white pits in finishing building.

It is also proposed to set up an adequate paper storage along with the storage for grey cotton goods adjoining the bleachery, and also convenient to a railroad track.

This establishes the combined requirements for this bleachery as follows:

New bleach house with capacity immediately for 1,000,000 yards per week in 40 hours and with space available so that a 25% further increase in production could be readily secured.

Location to be such that a short direct pull of cloth may be made from bleach house to present white pits.

Storage for 6,000,000 yards of grey goods adjoining railroad siding.

Space for grey goods and singe room.

Space for paper storage for 400,000 to 500,000 pounds of paper adjoining railroad siding and preferably at the same floor level as first floor of the present finishing building.

Space for chemical storage and mixing.

Floor Space Required in New Building . . . The outline of a new building for bleachery and storage is shown on drawing bound herewith and is estimated as follows:

Storage space for paper only	5000 sq ft
Space for grey cloth storage of 6,000,000 yards based on storing 3 rolls high on end as at present (with adequate aisles)	6000 sq ft
Space for opening up grey cloth, inspection, rewinding and sewing	4000 sq ft
Space for chemical storage, mixing, preparation, etc	2400 sq ft
Space for singe room and grey pits	1300 sq ft
Total in One-Story Space	18,700 sq ft
Space for bleach house—50 ft by 90 ft by 1 high story	4500 sq ft

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Estimated Cost for Scheme III . . .

Building construction including mechanical equipment, as follows:		
Bleach House 50 ft by 90 ft by 1 high story = 4500 sq ft @ \$6.00 including pile foundations	\$ 27,000.	
Chemic House 30 ft by 80 ft by 1 story = 2400 sq ft @ \$4.00	9600.	
Storage Building—1 story, without pile foundations = 18,000 sq ft @ \$2.50	45,000.	
Platforms, passageways, etc	4500.	\$ 86,100.
Estimated cost for moving and setting up bleach house in new location: Move one singer and gas piping	\$ 1000.	
Construct new steeping pits of concrete	1000.	
Move 6 kiers with pumps and heaters and including foundations @ \$600 each	3600.	
Move 5 squeezers including foundations, new boxes and drives @ \$800 each	4000.	
Move 7 square and 4 round wood bleaching tanks; need new foundations, probably new tanks	7000.	
Move and set up reels, poteyes, pit pilers and drives	2500.	
Supply piping for steam, water, and chemicals	7000.	
Move tanks, pumps, etc, in chemical department for preparation of chemic and sour solutions	3000.	
Supply new motor wiring	2500.	

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Construct new water supply line from filters and new connection to drains	1000.	32,600.
Move equipment in artificial leather plant:		
This scheme would involve moving three coating machines from north end of line to the south end of line to provide space for extending dope department and would provide for moving all embossing calenders and presses to a position considerably south of present location. Estimated cost as follows:		
Move 3 coating machines @ $2500 each	$7500.	
Move embossing calenders and presses as required	6500.	
Move and rearrange dope mixing department equipment as required	3000.	17,000.
Estimated cost of necessary changes to adapt vacated space for best use by Artificial Leather Department:		
This would involve building a second floor in the area now occupied by kiers and bleaching tanks, and the moving of existing elevator from the southwest corner of the two-story space to the southwest corner of the new two-story space, in order that it would be as well located as possible relative to the Artificial Leather Department. The estimated cost for these changes in existing space is		10,000
Total to here		145,700.
Add 10% for Contingencies		14,570.
Total Estimated Cost for Scheme III		$160,270.

Floor Space Gained by Scheme III . . . would be as follows:

On 1st floor	11,930 square feet
On 2d floor	14,250 square feet
Total	26,180 square feet

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Advantages of Scheme III . . . It may be considered a slight advantage to have the bleach house nearer the white pits, as at present there is some fraying of very light fabrics when pulled across the street under the tunnel. It is believed that this condition can be eliminated by a better arrangement of the reels and cloth support, and that the length of the present pull is not excessive.

The question has been asked whether or not the present bleaching arrangement could not be substantially improved and cheapened on account of the fact that the present arrangement has been in use without change for many years. We find the present bleachery to be compact and economical, and since only 18 men are employed at the present time to get out a production of 1,000,000 yards per week and including two men spending most of their time in handling grey cloth, we believe that any further advantages and economies to be gained would be so slight that from the standpoint of moving the bleachery to get a more efficient layout, this should be considered as not offering any worth-while inducements.

Disadvantages of Scheme III . . . In addition to the higher cost as estimated above, there are other disadvantages to Scheme III, including the following:

The time required to provide the additional space would be substantially in excess of the time required for the other plans. The interruption to production would be worse. It would probably be necessary to provide some new equipment in the shape of new kiers, some new bleaching tubs, and other items in order to get a start made on production at the new bleachery location before entirely dismantling the old. The space to be gained is not so close to present manufacturing operations as in Schemes I and II. The character of the space to be obtained is not so good as would be obtained with Schemes I and II because the present bleachery building is of combustible construction and the second floor is not well adapted to carry heavy loads.

While not included in the estimate, it might be desirable to do something more on the question of fire walls with Scheme III in order to separate the hazard by limiting floor areas between fire walls. This would automatically be done with Schemes I and II by constructing fire walls at the points where new construction adjoins the old.

Scheme III requires carrying out all at once, and when complete would provide immediately more space than is needed

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right now by the Artificial Leather Department, but this scheme is not capable of being carried out in several steps, as the space is needed.

SUMMARY AND CONCLUSIONS

After studying the above comparative costs and results accomplished by the several schemes, we believe that Scheme II offers the best solution, and achieves the maximum benefits for the money to be spent. It has the further advantage that it is capable of being carried out in steps as the space is required.

We recommend the adoption of this scheme and also that the question of foundations be carefully investigated to the end that undue building settlement will be avoided. We recommend the erection of a reinforced concrete building, preferably of flat slab design on pile foundations with provision for an elevator of adequate size to be installed later. We recommend that the building be designed for four stories in height.

LOCKWOOD GREENE ENGINEERS, INC.

By *Samuel B. Lincoln*
Vice-President

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AN INTRODUCTION TO A FULL REPORT[5]

REPORT NO. 3644

ON

A GENERAL SURVEY OF AND DEVELOPMENT PROGRAM

FOR

THE PHILADELPHIA STATE HOSPITAL

BYBERRY, PHILADELPHIA, PA.

TO THE

GENERAL STATE AUTHORITY

HARRISBURG, PA.

Philadelphia, Pa.
June sixteenth
Nineteen forty-one

INTRODUCTION

In compliance with our instructions from the General State Authority, we have made a survey of the existing conditions and future needs of the Philadelphia State Hospital at Byberry, Philadelphia, for the purpose of developing a plan for the rehabilitation and expansion of the institution in order to relieve the present overcrowded conditions in patient buildings and provide adequately for the functional requirements and services incident to the care and treatment of patients, all to the end that the institution may be able to function effectively and efficiently as a modern hospital for the mentally ill.

The scope of our investigation, planning, and report has been in accord with the following summary of principal matters as set forth in our contract with you dated February, 1941:

1 A thorough examination and inspection of the present buildings, steam and electric generating plants, and other general institutional service facilities to determine:

(a) A program of rehabilitation measures, with respect to buildings and service facilities, considered immediately necessary, and

[5] Report supplied by Day & Zimmermann, Inc.

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(b) A program of additions and improvements considered immediately necessary.

(c) A reasonable approximation of the costs of carrying out the work contemplated by (a) and (b).

2 A study in cooperation with The General State Authority representatives of the Department of Welfare of the Commonwealth of Pennsylvania, the Superintendent of the Philadelphia State Hospital, and such other Architects and persons as may be designated by the Executive Director of The General State Authority.

(a) The present, near future, and probable further requirements of the Institution, and

(b) The size or capacity, type, number, and arrangement of buildings and service facilities to best meet the requirements and provide a coordinated and effective functioning of the various departments and facilities, and

(c) Recommendations as to the type and general characteristics of the architecture considered appropriate to the functional needs and general setting of the Institution.

3 The formulation of a general plan for the progressive physical development of the institution, with enumeration of improvement items recommended for immediate provision, and of those recommended as permanent improvements for both present and foreseeable future needs. The latter are to be arranged in the general order of their necessity and sub-divided into groups representative of two (2) year steps and in accord with a program of needs determined in conjunction with the representatives of the Department of Welfare and The General State Authority, including matters such as:

(a) The determination of a program for the most effective utilization of the present buildings, plants, service facilities, and equipment—both temporary and permanent utilization—in the general development plan of the Institution.

(b) The preparation of maps showing the general arrangement and location of buildings and other facilities, typical general floor plans, and descriptions of the general characteristics of such facilities and major equipment items.

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(c) Estimates of the cost of the proposed improvements, suitably detailed and subdivided to accord with the two (2) year steps referred to.

When the scope of the survey was originally under discussion, and also when the contract was drawn, the consensus was that needed measures for the rehabilitation of existing buildings and service facilities and the additions and improvements immediately necessary could be determined independently of long range planning considerations, and provision was made for a preliminary report on these matters.

Very soon after the survey was under way, and as the extent of the inadequacies of the institution in dormitories, treatment facilities, and utility services became more concrete, it became evident that, with certain exceptions, it would not be sound procedure to reach conclusions as to the immediate needs until after reaching conclusions as to the expectable future growth, needs, and general plans for a functionally balanced institution.

Our representatives conferred with representatives of The General State Authority to the end that consideration was given to the future planning of the institution in preference to any temporary or immediate needs. As the work progressed, descriptive and cost information, and preliminary plans and recommendations were submitted for your immediate consideration, in lieu of a preliminary report, in compliance with the agreement.

The Philadelphia State Hospital, as at present equipped, is primarily a custodial institution, due to the lack of adequate facilities and staff for patient treatment. The addition of dormitory space alone would only perpetuate an institution not in accord with modern concepts of the functions of a mental hospital.

In the course of our studies, we have endeavored to develop, as our guide in planning, the functional requirements of a well balanced, first-class mental hospital; the facilities considered necessary for the care and remedial or corrective treatment of patients; the medical, nursing, and miscellaneous staff considered commensurate with the number of patients; and the housing and general service facilities essential to the institution as a whole. In these phases of our work we have conferred or corresponded with a number of hospital administrators, and psychiatrists of standing, studied plans of a number of mental hospitals, and made special inspection trips to three larger ones. We have also conferred with agents of The General State Authority and the State Welfare Department, and have had the fullest cooperation of the staff of the Institution.

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In determining the size, general characteristics, and number of buildings required, we have, after review of practice in other states, and to the extent applicable, adhered to such minimum standards for dormitory and day-room requirements as were prescribed by the Department of Welfare of the Commonwealth of Pennsylvania. The minimum standards for physicians, nursing and attendant personnel, as recommended by the American Psychiatric Association, have been used in determining personnel requirements.

The study and preparation of this report has been carried on by the following principal members of our organization and assistants, under the executive direction of Henry E. Ehlers, Vice-President.

Wm. A. Hemphill	Registered Engineer in Pa.
Harold T. Moore	" " "
J. N. Kennedy	" " "
C. D. Gibbs	" " "
Anthony J. Cossa	Registered Architect in Pa.

On account of the large size and amount of detail on some of our floor plans and other drawings, we are dividing our report into two sections with the text on standard size pages at the front of the report followed by photostatic plans with explanatory sheets of double width. A separate set of full size blueprinted plans accompanies the report as a supplement.

For convenience, our report is divided as follows:

SECTION NO. 1

I THE EXISTING BUILDINGS AND FACILITIES

II ANALYSIS OF POTENTIAL PATIENT LOADS AND REQUIREMENTS

III PROPOSED DEVELOPMENT OF THE INSTITUTION

IV SERVICE SYSTEMS AND FACILITIES

V COST ESTIMATES OF DEVELOPMENT PROGRAM

SECTION 2

PHOTOSTAT PLANS AND DESCRIPTIONS OF PROPOSED ALTERATIONS AND ADDITIONS

SUPPLEMENTARY EXHIBIT

A SET OF FULL SIZE BLUEPRINT PLANS OF PROPOSED ALTERATIONS AND ADDITIONS

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A SUMMARY OF A FULL REPORT[6]

Philadelphia, Pa.
April 7, 1941

Drexel & Co.
15th & Walnut Streets
Philadelphia, Pa.

Gentlemen:

Complying with your request, we have made an investigation of the property and business of The Connecticut Light and Power Company and its wholly owned subsidiaries for the purpose of arriving at opinions with respect to the territory served, the character, condition, and adequacy of the properties, the management, fixed capital, reserves, earnings and expenses, and other matters.

In the course of our investigation we made an inspection of the property and examined and analyzed the operating and financial records of the Company, including retirements. Among other things we have studied:

(a) the operating condition and adequacy of the facilities and their adaptability to the present service requirements;

(b) the electrical energy and gas production facilities, the contracts for the purchase or interchange of electrical energy and for the purchase of gas, and the manner in which the property is operated;

(c) the requirements for increased capacity and the steps which have been taken to provide for such increases;

(d) the balance sheet items with particular reference to the fixed capital account, the manner in which it has been created, the adequacy of the retirement reserve, as well as the past results from operations.

The results of our investigation and our conclusions with respect to the foregoing matters may be briefly summarized as follows:

The Connecticut Light and Power Company, which has been operating under its present corporate title since August 9, 1917, in addition to the electric, gas, water, and steam heating

[6] Report supplied by Day & Zimmermann, Inc.

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properties which it owns and leases, also owns subsidiary companies engaged in non-utility business: namely, The Windsor Locks Canal Company, The Shelton Canal Company, and The Rocky River Realty Company. The business and operations of these subsidiary companies as well as the water and steam heat properties are not significant in relation to the operations of the Company. The Company also owns The Connecticut Cable Corporation, a company which is at present inactive.

The Company renders in 110 towns, cities, or boroughs located throughout the State of Connecticut one or more of the following utility services: electric, gas, public water supply or steam heat. The area served by the Company is not continuous and includes properties in the eastern, central, and western part of the state with intervening areas served by other companies. Nevertheless, the major part of the territory served with electricity is inter-connected by transmission lines. The land area of the territory served comprises about 3235 square miles and according to the 1940 Federal census had a population of about 703,000 inhabitants. Generally speaking, the territory served by the Company, excepting that in the eastern part of the state, has a high density of population. Waterbury, the largest city in the service area, has, with its contiguous communities, a population of approximately 100,000. Other important communities served with electricity are Bristol, Meriden, New Britain, Norwalk, Putnam, Rockville, Willimantic, Winsted, and Greenwich. All of the above communities excepting New Britain and Greenwich are also served with gas.

The territory was adversely affected in past years through the migration of some of the textile industry from New England to the Southern states, but during the past decade the population has remained substantially constant. The industries in the territory are of a stable type and widely diversified.

The basic character and diversity of manufacturing activity is indicated by the following list, from among the Company's customers, of nationally known manufacturers:

The Conde Nast Publications Inc.	Publishing
Electrolux Corporation	Vacuum cleaners
Belding Heminway Company	Silk thread
General Electric Company	Plastic products
International Silver Co.	Silverware, table cutlery, etc
New Departure Mfg. Co.	Ball bearings
American Brass Co.	Brass sheet, rods, tubing
U. S. Rubber Products, Inc.	Rubber footwear, etc

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The Bristol Company	Recording and indicating instruments
Kerite Wire & Cable Co.	Insulated wire and cable
The E. Ingraham Co.	Clocks and watches
Landers, Frary & Clark	Household hardware, electrical appliances

The utility property of the Company is located wholly within the State of Connecticut and is directly owned by the Company except for a portion of the electric and gas property which is held under a 999-year lease from the Connecticut Railway and Lighting Company.

The Company owns and operates two steam electric generating stations and eight hydroelectric plants which have an aggregate installed rated capacity of 194,145 kw, of which 130,000 kw is in steam stations and the balance in hydro plants. All of the above power plants are interconnected by a transmission system excepting one small plant of 500-kw capacity serving the Winsted district which is isolated from the inter-connected electrical system.

The transmission system consists of 170.2 pole line miles of steel towers and 220.2 miles of wood pole or pole structures. Of these lines 214.4 miles are operated as a single circuit 66,000 volt loop and further construction now under way will increase the area served by the loop system. The aggregate installed capacity of substations, exclusive of customer substations, is 749,782 kva, including the step-up terminal substations located at the power plants. The electric distribution facilities serve about 107 communities and in the rural districts are in part carried on the same poles as the transmission lines. The number of customers served by these distribution facilities on December 31, 1940, was about 173,500.

Our inspection of the property indicates that the facilities are in a high state of maintenance. There is practically no property in service at this time which should be retired and it is our opinion that the property is in excellent physical condition.

The Company has contracts for the purchase of firm power with The Connecticut Power Company for the supply of a portion of its territory, the most important of the communities thus served being Bristol and Greenwich. It also purchases power from the Torrington Electric Light Company for the supply of energy in the area including Winsted, which is isolated from the interconnected power system of the Company. Other energy is purchased from The United Illuminating Com-

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pany, The Farmington River Power Company, The Hartford Electric Light Company, and a number of industrial companies. The Company's production and transmission systems are interconnected with the Stamford Division of the Connecticut Power Company, with which division an interchange energy agreement provides for the pooling and joint operation of power production facilities. The power requirements of the Company are adequately provided for by the above measures and the program for increased capacity in the production facilities of the interconnected system, which includes a 25,000-kw unit in the Stamford plant of The Connecticut Power Company which will go into service as of about September of this year, and a 45,000-kw unit which is expected to go into service in the latter part of 1942 at the Devon Station of The Connecticut Light and Power Company.

The gas production facilities of the Company include five carbureted water gas plants of which one is under the lease from the Connecticut Railway and Lighting Company previously referred to. These plants, which are not interconnected, have a combined rated capacity of 16,200 M cubic feet per day. In addition to the above the Company purchases coke oven gas from The Connecticut Coke Company, from which source there are available 11,000 M cubic feet of gas per day. This gas, which is received near New Haven, is transmitted by 59½ miles of mains which the Company owns, for local distribution to Bristol, Meriden, Middletown, and other communities and to Hartford where gas is sold at wholesale to The Hartford Gas Company. This line also connects with the lines of The New Haven Gas Light Company, with which company and The Hartford Gas Company the Company has an operating agreement for the pooling of production and purchased gas facilities. The distribution systems connected to the production and purchased gas facilities above described were rendering service, as of December 31, 1940, in thirty communities to 72,099 customers.

As a result of our inspection and study of the gas facilities of the Company we believe these properties to be in a high state of maintenance and it is our opinion that they are in excellent operating condition. In general it may be stated that the gas production facilities of the Company are amply adequate to take care of the demands of the system. On account, however, of the substantial increase in industrial consumption incident to the National Defense Program it may be desirable to increase the production facilities of the Company for the manufacture of carbureted water gas at Waterbury.

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The Company's rates for electrical energy and gas compare favorably with the rates of adjacent companies.

Average revenue per kilowatt hour for residential electric service has varied as follows during the past five years.

1936..........	5.15 cents per kilowatt hour
1937..........	4.83 cents per kilowatt hour
1938..........	4.48 cents per kilowatt hour
1939..........	4.09 cents per kilowatt hour
1940..........	4.02 cents per kilowatt hour

Industrial and commercial rates are principally of the two charge type, a demand charge and an energy charge. The average revenue per kwhr for commercial service during 1940 was 4.08 cents and for industrial power 1.40 cents.

The average revenue from all gas customers in 1940 was $1.09 per thousand cubic feet.

Voluntary reductions in the Company's rate for electric and gas service during the period from January 1, 1936, to December 31, 1940, effected savings to customers on an annual basis, as estimated by the Company, as follows:

Year Effective	Estimated Annual Savings to Customers
1936	$ 631,000
1937	157,000
1938	670,000
1939	413,000
1940	10,000
Total	$1,881,000

The management of the Company is under the direction of the President, whose offices and those of the general administrative staff are in Hartford, Connecticut. The officers of the Company who are responsible for the physical operation of the property, the new business departments, and the commercial and customers accounting departments are in the Company's offices at Waterbury, Connecticut. In Waterbury and other cities are located division and district offices responsible for local administration. Although the Company's operations cover a large part of the State of Connecticut, they are, nevertheless, within small compass and well coordinated. It is our opinion that the management of the Company is well organized and the business is being conducted efficiently. The personnel of the Company numbered 1,866 employees as of March 1, 1941. There is no record of disturbed employment

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conditions in the past history of the Company and there is every indication of loyalty on the part of the employees.

The Company is subject to regulation by the Connecticut Public Utilities Commission with respect to rates, service, and other matters.

The fixed capital account as carried on the books of the Company was in the amount of $103,516,279 as of December 31, 1940. This amount represents the acquisition cost of various constituent companies and expenditures made by the Company for additions to the property. It represents the cost to the Company of construction, and the cost to the Company, in terms of cash paid and par or stated value of capital stocks issued therefor, of acquisitions, a part of which acquisitions were from affiliates (see note 1 to Balance Sheet on page 44). Included in these additions to property is an amount of $15,221,635 to properties of the Connecticut Railway and Lighting Company, which are operated by the Company under a 999 year lease expiring in 2905. According to the terms of the lease, additions to the property during the life of the lease will be paid for by the lessor at their fair value at the time the property is turned back to it.

The Connecticut Public Utilities Commission has adopted a new Uniform System of Accounts for Electric and Gas Utilities effective as of January 1, 1941, which provides that the detailed utility plant accounts shall be stated on the basis of original cost, which means the cost to the person first devoting it to public service.

This regulation will necessitate a comprehensive analysis of the Company's fixed capital accounts, the effect of which cannot be determined at this time. The management has had no established rule as to the amount of the accruals to its retirement reserve. As of December 31, 1935, the retirement reserve amounted to $4,222,765, whereas on December 31, 1940, the reserve amounted to $7,741,864, indicating a substantial increase in spite of retirements amounting to $4,360,175 during this period. There are at present little or no deferred retirements existing in the property and the Company is faced with no major retirements in the near future. It is our opinion that the Company is currently providing by charges to operating revenues an adequate provision for retirements, when considered in the light of the Company's maintenance policy.

The consolidated earnings and expenses of the Company and its subsidiaries, as now constituted, for the past five years are briefly summarized as follows:

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OPERATING EXPENSES

Year	Operating Revenues	Operations*	Maintenance	Provision for Retirements	Taxes Including Federal Income	Adjusted** Reported Net Income Applicable to Common Stock — Amount	Per Share
1936	$18,667,389	$7,833,799	$1,347,147	$ 919,415	$1,735,756	$3,744,489	$3.26
1937	19,719,212	8,297,073	1,404,854	1,830,606	1,829,344	3,803,166	3.31
1938	18,740,981	7,813,312	1,622,225	1,294,033	1,911,336	3,478,556	3.03
1939	19,774,038	8,198,993	1,232,335	1,791,300	2,100,096	3,793,205	3.30
1940	21,266,196	9,000,198	1,344,592	1,970,586	2,606,146	3,708,964	3.23

* Including provision for doubtful accounts.

** The adjusted net income applicable to common stock in this summary differs from that stated in published reports of the Company (unconsolidated) from 1936 to 1940 due to (a) the exclusion from the summary of net losses of two small subsidiaries sold prior to December 31, 1940, and (b) the inclusion therein of earnings or losses of subsidiaries of the Company since December 31, 1935. The net adjustments in the respective years are as follows:

1936	1937	1938	1939	1940
$9758	$3764	$1121 (loss)	$1425 (loss)	$19,508

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The sufficiency of the expenditures for maintenance is evidenced by the excellent operating condition of the property.

In our opinion, the ability of the management to earn income as shown above during the period, despite rate reductions and rising taxes, evidences a high order of stability in the Company's business, and demonstrates an ability to meet changing conditions.

Very truly yours,

DAY & ZIMMERMANN, Inc.

Theodore E. Seelye

Vice-President

Examination reports without recommendations. Examination reports without recommendations observe in the main the same technic as examination reports with recommendations. The only difference in content is that the investigator is not asked to express his advice about future action. It may be that no immediate action is contemplated, as in the case of a report on some part of a technical process; or it may be that the person ordering the report is himself capable of making his own decisions on the basis of the facts discovered by the investigator. Hence, only the conclusions established by the investigation are stated, and recommendations are not submitted.

Most undergraduate reports are examination reports without recommendations. Undergraduate reports are, of course, five-finger exercises, and it is practically impossible to simulate in them actual professional conditions. One serious handicap which the student report writer has to face is lack of technical knowledge, at least during the earlier years of his course. The best reports spring only from fullness of experience and training. But the student should make the most of the materials at hand and let his reports approximate the best professional practice in respect to preparation, organization, and style, if not in actual substance.

Lack of specific knowledge must not be hidden behind a smoke-screen of words and non-significant details. Be sure that your investigation will be judged not on the number of words in your report but on the orderliness of its organization and the substantial quality of the facts presented. Graphs, diagrams, and other exhibits should be used wherever they will serve a useful purpose, but they are not for decoration and cannot cover up paucity of information or slovenliness of composition.

A report on a laboratory experiment demands a clear, impartial statement of materials provided, methods employed, and results ascertained. It is usually written in the third person. The writer must determine at the beginning whether his results shall be tabulated, or set forth in one carefully developed paragraph, or developed into a report of several connected paragraphs. Such a report demands the greatest economy in the use of words, what is wanted being merely an exposition of facts. The order of such reports is usually as follows:

(1) The object of the experiment
(2) The theory that underlies the operation

(3) Description of the apparatus used
(4) The methods employed
(5) The results

If diagrams are used, they should be accurately numbered and lettered, and at proper places in the text references to them should be inserted.

A report on a visit of inspection to a manufacturing plant will show in the first place the particular arrangement of apparatus or methods of work adopted in the plant, and in the second place, ideas about the apparatus or methods in use that have come to the student in the course of his inspection. For the writing of such a report, careful note taking and working up of notes are indispensable. Notes hastily jotted down, with no particular method in selection or arrangement, will not suffice. Significant headings and clearly defined subdivisions are necessary if the writer expects the report based on his notes to be accurate and complete. In taking notes, the student should be sure that he has recorded sufficient information for the later writing up of the report. A good plan for this kind of report is:

(1) An introductory sentence or paragraph giving the necessary general information about the size of the plant, the kind of work done, the output, etc.
(2) Treatment of the main features of the plant, discussed in the order of importance, the order of observation, or any other order which seems logical and which conveys to the reader a clear idea of the interrelation of parts.
(3) A final paragraph or series of paragraphs containing the writer's conclusions on the character of the plant and its method of operation as a whole.

The technic of the examination report without recommendations, as was indicated above, is in the main identical with that of the examination report with recommendations. The discussion of this type of report in this chapter will therefore be limited to the foregoing comment on two kinds of student reports and to the extended treatment of the Research Laboratory Report which will follow shortly. The four specimens which are now presented comprise three student laboratory reports from different divisions of engineering and one professional investigation report. The examples of examination reports with recommendations which immediately precede this

section will serve further for purposes of study and, possibly, imitation.

EXAMINATION REPORTS WITHOUT RECOMMENDATIONS

1

[A student report]

TENSION TESTING OF AN S.A.E. 1020 STEEL
"DROP OF THE BEAM" METHOD

Object of the Experiment

The object of this experiment was to detect the point where a "drop in the load" occurred and, further, to analyze the yield strength of a 1020 steel when it was loaded in tension.

Theory

Whenever a specimen of any ductile metal is gradually loaded, a strain is set up in the material which, at first, gives the material a deformation directly in proportion to the load. After passing a certain point, known as the proportional limit, this proportionality ceases to exist and the unit strain increases at a more rapid rate than does the unit stress. This rapid deformation proceeds until a distinct "stop" in the increase of the load occurs. The stress corresponding to this load value is known as the yield strength.

Description of Apparatus and Materials

A Tinius Olsen, 100,000-lb testing machine was used as the loading device in this test. It was belt driven by a 2-horsepower, synchronous motor and was clutch controlled so that four speeds were obtainable. The instruments used in measuring and computing the data consisted of a ½-in. micrometer and a slide rule.

Procedure

While the load was being applied to the specimen, the lever arm of the machine was kept in a balanced position by running the poise at approximately a steady rate. As the yield strength of the material was being reached, however, this rate decreased until the lever-arm dropped and no further change in the poise setting was then necessary. After the diameter of the cross section at the "drop of the beam" had been measured by means of the ½-in. micrometer, the area was then computed by the use of a slide rule. Likewise the load at the instant the lever-arm dropped off was recorded

and, by means of the formula s = P/a, this load was used in computing the yield stress.

Results

At the instant the load dropped, the diameter measurement and the load reading were 0.462-in. and 5880-lb, respectively. The computed area then became 0.168-sq in., and the calculated yield stress amounted to 35,000 psi.

2

[A student report]

SYNCHRONOUS MOTOR

Object

The object of this experiment was to determine the excitation characteristic of a synchronous motor.

Theory

A synchronous motor has the same structure as a synchronous generator. As in a generator, the field is separately excited by direct current; the armature is supplied from the line with alternating current, either single phase or polyphase. The speed is fixed by the frequency of the supply circuit, that is, the motor runs at synchronous speed or not at all. In starting a synchronous motor it is first necessary to bring it up to speed, usually by external means, and this limitation has prevented its more general use. The fixed speed is a positive advantage. A synchronous motor has the additional advantage that its power factor may be adjusted to be leading or lagging, to suit the particular need.

Description of Apparatus

A General Electric alternator, 1800-rpm, 13-amp, 220-volt, was run as a synchronous motor in this test. It was shaft-connected to an induction motor. The direct current in the field was supplied by a Wood Generator, shaft-connected to a Wood motor. A wattmeter was placed in the line to measure the power to the motor. A voltmeter and an ammeter were used with the wattmeter. A voltage transformer was used to reduce the voltage to the motor; an instrument transformer was used to limit the current to the motor.

Procedure

An ammeter, voltmeter, and wattmeter were connected in the armature circuit. A rheostat and ammeter were connected in the field circuit. The motor was synchronized with the main switch. The motor was then run at no load, with the field current varied through as wide a range as was possible. Simultaneous readings were taken of all instruments. The power factor, phase angle, power component, and wattless component were computed from the data and plotted on cross-section paper, using the field current as the abscissae in every case.

Results

Field Current	Armature Current	Armature Voltage	Watts Input
0.355	4.6	70.5	270
0.295	4.1	69.5	265
0.227	4.3	69.0	265
0.160	5.6	70.3	290

Phase Angle	Power Factor	Power Component	Wattless Comp.
33.72°	83.3%	3.82	2.54
21.30°	93.1%	3.82	1.50
26.54°	89.4%	3.84	1.93
42.28°	73.7%	4.13	3.79

3

[A student report]

DETERMINATION OF SURFACE TENSION OF LIQUIDS BY CAPILLARY HEIGHT METHOD

Object of Experiment

The purpose of this experiment was to determine the surface tension of a pure liquid over a temperature range.

Theory

The simplest and most direct method of determining surface tension of liquids consists in measuring the rise of a liquid in a capillary tube. If one end of a capillary tube is immersed in a liquid which wets the glass, the liquid rises in the tube beyond the level of liquid outside the tube. This rise of the liquid in the capillary tube is dependent upon the nature of the liquid, the radius of

the capillary, and the temperature. Therefore the surface tension of a liquid may be expressed by the following formula:

$$c = \frac{rhdg}{2}$$

where

c = surface tension in dynes per centimeter
r = radius of capillary tube
h = height of capillary tube
d = density of the liquid
g = acceleration of gravity

Apparatus

The apparatus used in this experiment consisted of a capillary height tube, a thermometer, and a constant temperature bath.

Procedure

The capillary tube was thoroughly cleaned and dried. It was then placed in a containing vessel partly filled with the pure liquid which was to be measured. The capillary tube was suspended in such a manner as to have one end immersed in the liquid. The whole system was then suspended in a water bath at a temperature of 20°C. From time to time the vessel was shaken to insure proper temperature equalization in the liquid. When thermal equilibrium was established, the capillary was thoroughly wetted by raising and lowering the liquid in the capillary several times. This wetting was accomplished by alternate suction and blowing through the side arm of the container. The meniscus was allowed to come to rest and the height of the liquid column was measured by use of a scale or a cathetometer. Five readings were taken. Between successive readings the meniscus was made to rise in the capillary and then resume its equilibrium position. The average of the five readings was taken as the capillary height. The entire procedure was repeated with the water bath at temperatures of 40°C, 55°C, and 70°C.

Results

The results obtained from this experiment showed that the surface tension of a liquid varies inversely as the temperature of the liquid. The individual surface-tension values that were obtained in this experiment were found to be in agreement with similar data from the literature.

4
BRIEF INVESTIGATIONAL REPORT WITH CONCLUSIONS[7]

DAY & ZIMMERMANN, INC.

ENGINEERS

NEW YORK **PHILADELPHIA** CHICAGO

PACKARD BUILDING
PHILADELPHIA

SUBJECT Proposed Street Loop—Route 26
FILE No 3516-10

June seventeenth
Nineteen forty

The Executive Committee
Board of Directors
Philadelphia Transportation Company

Gentlemen:

The proposal of the Management to construct a turnback loop for Route 26 on city streets at the intersection of Chew Street and Chelten Avenue was referred to us for report in connection with the budget. The general relation of the proposed loop to the existing facilities used by Route 26 is shown on the attached map. The results of our field and office studies are summarized below.

THE PRESENT SITUATION AND THE PROPOSED TURNBACK

Route 26 is operated between Fox Chase and Germantown via Rising Sun Avenue, Olney Avenue, Chew Street, and Chelten Avenue. It is a very important crosstown feeder to Broad Street Subway, with which it connects at Olney Avenue terminal. On the western end it runs through the heavily congested Germantown business section. Passenger traffic on the longer section of the route lying to the east of Broad Street is much greater than on the section west of Broad Street, and is particularly dense between 5th and Broad Streets. This additional traffic is handled in rush hours by the operation of

[7] Report supplied by Day & Zimmermann, Inc.

short trips between loops located at Rising Sun and Olney Avenues, and at Broad Street. The short-routing at the Broad Street end is accomplished by looping around the Olney Avenue subway terminal, which provides a very economical operation for the added service but is subject to the objection that the turning is done at a congested location over tracks used by other routes.

The amount of service at present operated between Broad Street and Germantown is determined by the passenger loads at Broad Street. West of Chew Street and Chelten Avenue the rush period traffic is about 45 per cent of the traffic at Broad Street. It would be feasible to turn back a portion of the present rush hour service in the vicinity of Chew Street and Chelten Avenue if turnback facilities existed. Such turnback service has been estimated by the Company to result in an economy of about $2200 per annum. The estimate assumes that the present short trips operated east of Broad Street will continue to be turned back at Olney terminal. We concur with this estimate.

A loop in the general location proposed would also make it possible to extend advantageously some or all of the short trips west of Broad Street in order better to meet the needs of increasing traffic due to new developments along Olney Avenue, including the new Central High School, LaSalle College and Stadium, and residential developments. Such extension would relieve the congestion at the Broad Street loop and would be considerably cheaper than extension of this service to the western end of the line. The Company has estimated that the extension of all of the present short trips to the proposed loop would cost about $4100 per annum. Extension to the western end of the line would cost about double this amount.

Consideration of the proposed turnback facilities from the viewpoint of schedule adjustment is at least equal in importance to that of its possibilities for regular service turnbacks. Route 26 is operated by one-man crews and is subject to schedule irregularities due principally to congestion in Germantown. Turnback facilities at the proposed location would provide the means for such adjustments at a westerly point which would entirely by-pass the congested section in Germantown and at the same time avoid service cuts over the major portion of the route.

In addition to its primary uses as outlined for Route 26, the loop would provide an emergency connection between Chelten Avenue and Chew Street which could be used to detour the York Road and Ogontz Avenue lines to Olney subway terminal in case of blockade on these lines south of Chelten Avenue.

THE PROPOSED TURNBACK LOOP

The proposed loop as planned by the Company is entirely on city streets. It involves the construction of 262 feet of tangent track on McMahon Avenue and 438 feet on Woodlawn Avenue, with a connecting curve between, and with connecting curves to the existing track on Chelten Avenue and Chew Street. The estimated construction cost is $21,000, allowance for which has been made in the 1940 Budget. McMahon and Woodlawn Avenues are built-up residential streets. They are 50 feet wide with 30 foot and 26 foot paved cartways, respectively. Some tree trimming will be necessary.

The location of the proposed loop is the most desirable one available for such facilities on city streets. The construction of a loop on private property acquired for the purpose at or near this location would probably cost much more than the proposed highway loop, which in our opinion would serve the railway purposes equally well. Such a loop, however, is likely to encounter some objections from residents along the streets concerned. It is our understanding that the construction would have to be preceded by an authorizing ordinance by City Councils and by the approval of the Public Utility Commission.

CONCLUSIONS

In conclusion, we consider the proposed loop facilities desirable for the adjustment of schedule irregularities and the economic possibilities of turning back excess service now operated to Germantown in the rush hours, and for its potentialities in respect to economical provision for carrying the growing traffic in the sections of Olney Avenue west of Broad Street and for emergency detouring of Routes 6 and 55.

We recommend approval of the project and authorization of measures to secure the necessary public consents and approvals.

Very truly yours,

DAY & ZIMMERMANN, Inc.

H. E. Ehlers

H. E. Ehlers
Vice-President

RESEARCH EXAMINATION REPORTS. The formal laboratory research report is a type of examination report which may or may not entail recommendations. If the investigation is pursued in the interest of pure science, it is likely to stop with the formulation of conclusions; if it pertains to applied science, it is likely to make recommendations about the use of the facts discovered.

Stripped to its essentials, the research report is built on the following plan:

Preliminaries
- Title page
- Table of contents
- Summary

Body
- Statement of the problem
- History of the subject
- Description of the present study
- Conclusions and recommendations
- Plans for future work

Appendix
- Supplementary data
- Bibliography

Preliminaries. The importance of the preliminaries can not be overestimated. They should receive and reflect at least as much care as the body of the report, for to the reader they will be indicative of the quality of the report proper.

1 Title page. The title page gives the subject under study, the name of the writer, the name of the client for whom the report has been prepared, and the date. In research reports the title must be so fully phrased as to be self-explanatory; short-cuts are not permissible.

2 Table of contents. The table of contents differs in no respect from the one already described on page 230.

3 Summary. The summary is easily the most important part of the research report. Inasmuch as the letter of transmittal or the foreword is rarely used in this type of report, the summary takes on added importance. It aims to give the reader previously unacquainted with the subject an immediate understanding of what was to be done, how it has been done, and what has been gained. All this must be compressed into

the space of one or two typewritten pages. Because of this extreme condensation, great care must be taken to make the meaning of every statement unmistakably plain and clear. The summary may include the following items:

> *Nature of the problem.* The nature of the problem is described, and the purpose and the scope of the investigation are defined.
>
> *Outline of procedure.* The main steps in the experimental procedure are abstracted from the body of the report and set down in order. The results of the experimentation are stated and briefly discussed.
>
> *Conclusions and recommendations.* The conclusions show the significance of the results. Recommendations for subsequent action based on these conclusions are offered if required.

The summary is usually written after the body of the report; but it is not impracticable, sometimes, to make a rough draft of the summary before writing the body, simply that you may fix in mind the high lights of the report. In the latter case the summary is, of course, entirely rewritten after the report proper has been completed.

Body. The body, or report proper, is itself divisible into several kinds of information.

1 Statement of the problem. Material which, in some types of reports, appears in the foreword or the letter of transmittal, will be found in the introduction to the main text of the research report. Already briefly mentioned in the summary, the purpose and the scope of the investigation are here defined as fully and particularly as may be necessary. This section is usually short, but it is fundamental to a clear understanding of the experimental procedure. At this point, also, may be inserted a definition of any terms likely to be misinterpreted by the reader. Remember that definition is a process of limiting the possible meanings of a term, and that this process is both positive and negative: all the pertinent meanings of the term are included in the definition; all other meanings are excluded.

2 History of the subject. In the report of a laboratory experiment, the history of the subject is generally a presentation of the matter of previous investigations. Presumably the laboratory work has been preceded by the study of articles in

the literature of the subject. These articles may be briefly summarized, with mention of the conclusions of each investigator. References should be made, by footnote, to the bibliography at the end of the report. In case previous reports on the same or related subjects have been furnished to the same client, a short synopsis of such reports may save your reader the trouble of referring to them.

3 Description of the present study. This section is the core of the research report. It will take many different forms. The guiding principle of the writer in organizing this section is, however, a simple one: so to lay out his material that subsequent investigators can repeat or follow up his lines of research. This section will include descriptions of materials and of apparatus, principles governing the process under investigation, experimental procedure, results and discussion, conclusions and recommendations, and plans for future work. The apparatus should be described in great detail. The section on experimental procedure deals with method only. The section on results and discussion affords a transition between experimental procedure and conclusions.

4 Conclusions and recommendations. The conclusions follow directly the results of the experimental work. They are usually best arranged in a series of short paragraphs or statements, parallel in form. The recommendations, like the conclusions, should be compact and precise.

5 Plans for future work. The nature of the concluding section, plans for future work, is obvious from the heading.

Appendix. Following the report proper, the appendix includes all supplementary data and the bibliography.

1 Supplementary data. Calculations, formulas, graphs, diagrams, statistics, exhibits, and other material which would break the continuity of the text are relegated to the appendix. But such illustrative matter as closely pertains to the text should be kept as near as possible to statements referring to it. No point is served in removing a vitally essential diagram from the body of the report to the appendix.

2 Bibliography. Since the research report usually entails a greater amount of reading and study than other examination reports, the bibliography is especially important. At the end of the report, a full list of references consulted should be given.

SUPPLEMENTARY SUGGESTIONS

The following excerpts from various companies' suggestions or regulations for the writing of technical reports will supplement the preceding discussion of the research report.

A

The first excerpt comes from the Experimental Engineering Department of the South Philadelphia works of the Westinghouse Electric and Manufacturing Company. Mr. R. P. Kroon here suggests several possible forms for reports of varying length and content.

1

Short Report (2-3 pages)

Introduction
Subject Matter
Conclusions and
Recommendations

2

Medium size report describing analytical work or new calculation method

Summary
Introduction
Theoretical Background
Analysis (or method)
Conclusions
List of Symbols
(Appendix)

3

Medium Size Test Report

Summary
Introduction
Test Setup
Test Results
Discussion of Results
Conclusions
List of Symbols

4

Extensive Test Report

Table of Contents
Summary
Introduction
Tests Conducted
Testing Equipment
Procedure
Analysis of Tests
Conclusions and
Recommendations
List of Symbols
Appendices

B

The second excerpt, which is taken from the Manual of Report Procedure of the Research Laboratories Division of the

General Motors Corporation, consists of (1) a discussion of the divisions of the report and (2) specimen pages (title page, foreword, conclusions, recommendations).

1

DIVISIONS OF THE REPORT

Reports are read by people in various positions and from different points of view. For the busy executive, interested only in the high lights of the investigation, a short, concise statement of the problem, the conclusions arrived at, and the recommendations may be all that is necessary. The engineer, on the other hand, may require more detailed information. He may wish to know how tests were conducted, the instruments used, and the analysis of the data compiled. To suit the needs of all it has been found best to divide and arrange the report as follows:

Foreword

The foreword or introduction defines the subject, scope, and purpose of the report. It may explain why the work was undertaken and upon whose authorization. Reference to other reports on the subject is desirable.

Conclusion

The conclusion of a report summarizes the results of tests made and records discoveries. The foreword and conclusion are the most difficult parts of the report to write. The foreword states the problem and the conclusion interprets the results. This interpretation should be written in such a manner that a reader less specialized than the writer has no difficulty in comprehending the report.

Recommendations

When recommendations are expressed, they should be placed under a separate heading, "Recommendations," and given emphasis by simple, forceful expression, by being set off on separate lines or paragraphs as the following: We, therefore, recommend that: *or*, We also recommend that:

Discussion

The discussion is the body of the report and contains the data collected during the investigation. These data may be tabulated or charted and are usually explained and interpreted as the need requires. Whenever possible it is advisable to put the numerical test results under a separate heading: Results of Tests.

2

SPECIMEN PAGES

(TITLE PAGE)

Report Number OC-52
Project Number 10

Number of Pages 51

RESEARCH LABORATORIES DIVISION
GENERAL MOTORS CORPORATION

Detroit, Michigan

THE EFFECTS OF SOME ENGINE VARIABLES ON THE HEAT LOSSES FROM THE INFLAMED CHARGE AND THE OCTANE REQUIREMENTS OF THE ELL-HEAD TEST ENGINE

Reported by:
Howard B. Felder
Lloyd L. Withrow
Organic Chemistry Department

Approved by:

T. A. Boyd, Head of Department

H. C. Mougey, Technical Director

December 4, 1940

FOREWORD

A study is made of the relative effects of quartz, cast iron, and aluminum cylinder heads on the magnitude of the heat losses in an internal-combustion engine during combustion and expansion of the mixture. This work was suggested by observations which indicated that about one fifth of the heat of combustion is lost during inflammation when a quartz head is used.

To shed some light on the causes of these high heat losses and on their subsequent effect on the thermal efficiency of the engine, the following steps have been taken, using three different cylinder head materials:

(1) Heat losses during expansion of the inflamed charge under comparable engine conditions

(2) Heat losses during inflammation of the charge

(3) Octane requirements of the engine while operating with each of the three head materials.

CONCLUSIONS

The conclusions formed from this study may be summarized as follows:

(1) The quantities of heat lost from the charge during combustion and expansion were 14% and 30%, respectively, of the total heat of combustion.

(2) The heat loss during inflammation was several-fold greater than the loss during expansion even though (a) the expansion period was nearly twice as long as the inflammation period, (b) the combustion space was entirely filled with the inflamed mixture during expansion, and (c) the wall area increased as the mixture expanded.

(3) The heat lost during combustion and expansion decreased to about 70% of its original value when the speed was increased from 1000 to 2000 rpm.

(4) The heat lost during combustion and expansion increased slightly when the temperature of the cast iron and aluminum heads was increased by stopping the flow of coolant through them. The causes of this phenomenon are not fully understood.

(5) The heat losses during combustion and expansion do

not appear to be related directly to the thermal conductivity of the head material.

RECOMMENDATIONS

A study should be made to determine the relationship between the heat losses which occur during combustion and expansion of the charge and the thermal conductivity of the head material.

It is further recommended that an investigation be made of the causes of the increase in heat loss occurring when the flow of coolant through the head is restricted.

C

The third excerpt consists of the headings from the Standard form for research reports which is approved by the Monsanto Chemical Company.

OUTLINE

Introduction
Summary
Conclusions
Patent Situation
General Outline of Work
Literature or Patent References
Reference to Previous Work
Raw Materials Used and Specifications
Apparatus Used
Experiments
Description of Process Recommended
Discussion of the Work
Analytical Methods Used and Product Specifications
Bill of Materials per 100# of Finished Product
Cost Calculation
Results on Plant Scale
Recommendations for Future Work
Acknowledgment

D

The fourth excerpt consists of an outline of the body of a progress report on experimental laboratory research. It has been formulated by the Chemical Department of the Experi-

mental Station of E. I. duPont de Nemours & Company, Inc.

Outline

Introduction (broad objective or goal of the investigation)
Objective (a two- or three-line statement)
Summary and Conclusions (normally, not more than one page in length)
Patent Situation
Program (brief but informative statement as to the next step in the work)
Experimental Details (brief, preferably from two to five pages in length)

E

The fifth and last excerpt is taken from the regulations for student research reports which are issued by the Division of Chemical Engineering of the University of Delaware.

Outline

- Title Page
- Letter of Transmittal
- Table of Contents including
  - List of Figures and Tables
- Summary
- General Discussion
  - (a) Statement of Problem
  - (b) Theory
  - (c) Experimental Method
    - Apparatus
    - Procedure
  - (d) Results
    - Experimental Data
    - Calculation of Results
    - Correlation of Results
    - Discussion of Results
- Table of Nomenclature
- Appendix

Study the examples of research reports which follow, bearing in mind the ideas developed in the preceding discussion and in the excerpts.

RESEARCH REPORTS

1

FIELD TESTS FOR WHEEL LOADS[8]

By H. R. Thomas

12 Object of Tests. As a result of the rolling-load tests in the laboratory it was found that the minimum wheel load which would cause a shatter crack to grow in size and become a transverse fissure was approximately 40,000 lb. This wheel load was somewhat higher than the usual locomotive driver load, and much higher than the wheel loads for heavily loaded freight cars. Since it seemed probable that transverse fissures were the result of the application of a relatively large number of wheel loads (more than could be expected from the number of driver loads passing over the rail) it was felt that tests should be made in order to answer the following questions:

1 Do heavily loaded freight cars have occasional wheel loads equal to or greater than the 40,000 lb mentioned in Section 9?

2 If high wheel loads are found under freight traffic, how frequently do these occur?

3 If high wheel loads are found, what is the reason for their occurrence?

13 Test Methods and Apparatus. In order to accumulate the necessary statistical data concerning the magnitude and frequency of high wheel loads, it was decided to base such determinations on measurements of average longitudinal strain at the center of the base of the rail. Since such average strain is very nearly proportional to the wheel load causing the strain, the problem resolved itself into devising a means for recording the strain under each locomotive and car wheel for the usual freight train passing over the test location.

It was decided that the recently-introduced DeForest scratch strain recorder would be the simplest method of measuring such strains, provided it would give satisfactory records under the severe impact and vibration conditions found in a railroad rail during the passage of a train. A trial instrument was obtained and used on the tracks of a local railroad .

[8] This research report constitutes a section of the Seventh Progress Report of the Joint Investigation of Fissures in Railroad Rails.—Editor's note. It is reprinted from Proceedings of the Forty-Second Annual Convention of the American Railway Engineering Association, Vol. 42 (Chicago, 1941), pp. 692-696.

in order to try it out. It was found that by making some modifications in the instrument and by introducing rubber padding for damping vibration of certain parts, satisfactory records could be obtained. Ten of these instruments were purchased and mounted on clamps which could be attached to the base of the rail at points where measurements were desired. Figure 6[9] shows this strain gage and its attachment to the rail.

The principle of operation of scratch strain gages is very simple: The total strain in the rail in the four-inch gage length is recorded, without magnification, by a diamond point scratching on a chromium-plated brass strip. Movement of the strip, due to the strain being recorded, is produced by a spring whose action is influenced by the variable friction introduced by the relative movement of the two ends of the instrument, and results in a separation of the ordinates which is proportional to the magnitude of the wheel load as the wheel passes over the instrument. The rate of feed can be controlled by variation of spring tension and of the friction acting on the plate carrying the record strip. With proper regulation of friction and spring action it was possible to obtain records showing the strain in the rail for each wheel of a 40-car train.

This original form of the scratch strain gage was used for tests made at Dayton, Ohio, and at Coatesville, Pa. After the completion of these latter tests, ten new instruments were built in the University[10] shops, embodying the general principles of operation of the original instruments, but including certain changes which made them more suitable for the tests of wheel loads in service. The changes made included: (1) more rigid construction to prevent vibration; (2) use of celluloid pads coated with diamond dust instead of the single diamond recording point; (3) strictly interchangeable parts with spare parts available for substitution in case of necessity. In most cases parts were replaceable without removing the instrument from the rail.

These ten revised instruments were used on the tests at Rome, N. Y. After the tests at Rome, 10 additional instruments were made, and all 20 were used in the tests at Matfield Green, Kans.

14 Interpretation of Results. In order to determine wheel loads from the measurements of mean strain in the base of

[9] Figures 6, 7, and 8 are omitted in the reproduction of this report.—Editor's note.
[10] University of Illinois.—Editor's note.

the rail, use was made of the mathematical analyses reported by Professor A. N. Talbot in the Sixth Progress Report of the Special Committee on Stresses in Railroad Track.[11] Considering a group of four adjacent freight car wheels, the bending moment under a given wheel may be reduced by the effect of adjacent wheels, but if there is a dynamic augment in a given wheel load (due, for example, to a flat wheel) then the increase in bending moment at that wheel will be very nearly proportional to the increase in wheel load. Since the measurements of strain in the base of the rail permitted calculations of corresponding bending moments, the above relationship was used for computing the dynamic increase in wheel load. Bending moments due to static wheel loads were determined from runs over the instruments at sufficiently low speeds (5 miles per hour) to avoid dynamic effects for cars with wheels in good condition.

15 Results of Tests. Over a period of three years, tests for frequency of high wheel loads for freight cars were made as follows:

September-October 1933. On the B. & O. north of Dayton, Ohio, on the 130-lb test rail laid in 1932. Tests were made at two locations, one being near the beginning of the test rail at North Dayton, and the other near the north end of the test rail at Vandalia. On this single track line a considerable percentage of the traffic consisted of loaded coal and ore cars, with some refrigerator and box cars.

February 1934. A few tests were made using a special train containing cars with flat, badly worn, and shelled wheels. Effect of frozen railbed was also studied in these tests.

September 1934. Tests were made on the eastbound freight track on the main line of the Pennsylvania Railroad west of Coatesville, Pa. These tests were on 152-lb rail. Traffic consisted largely of loaded coal cars.

July 1935. Tests were made on the New York Central Railroad near Rome, N. Y., at three locations: 1. Near Greenway, on 105-lb Dudley rail, the track being in rather poor condition. 2. East of Rome on 127-lb Dudley rail. 3. On 105-lb rail on a steel bridge east of Rome. This rail on the bridge was laid with GEO construction, the ties being supported directly on the bridge stringers. The test was for the purpose of determining the effect on dynamic wheel loads of

[11] See AREA Proceedings, Vol. 35, 1934, p. 278.—Editor's note.

very rigid rail support rather than for determining impact loads on a bridge. A few instruments were placed near the bridge, also on GEO track, for comparison.

Traffic over these test sections was mostly mixed freight, including refrigerator cars with some coal cars.

May-June 1936. Tests were made on the 110-lb test rail laid on the Atchison, Topeka & Santa Fe near Matfield Green, Kans. This is a single-track freight cut-off carrying mixed freight with many refrigerator cars and oil tanks. Tests were made using 20 instruments at two locations: (1) On normal tangent track; (2) on a ballasted deck, timber, pile-supported trestle. The bridge, in general, differed little in stiffness from the normal track.

In Figures 7 and 8 there are presented load-frequency curves, giving the results of tests on the four railroads. It will be noted that in Fig. 7 the curves for tests on the Baltimore & Ohio and the Pennsylvania railroads show good agreement, while the curves for the tests on the New York Central and the Atchison, Topeka & Santa Fe Railroads are about 10,000 lb lower than the others. A study of the train sheets indicated that there was approximately a 10,000-lb difference in the average wheel load for the loaded cars for these two groups of curves.

In Fig. 8 the curves for tests on the bridges on the New York Central and the Santa Fe are shown, the curves for tests on the same roads at sections not on the bridges being given for comparison. It will be noted that for the tests on the Santa Fe the curve for the bridge tests is not greatly different from that for track away from the bridge. This is to be expected, since this ballasted-deck bridge was of approximately the same stiffness as the regular track. The higher wheel loads indicated by the curve for the bridge on the New York Central were undoubtedly due to the fact that the ties were supported directly on the bridge stringers, which resulted in a very stiff track support.

16 Conclusions. Based on a study of the results obtained on the above tests, including a study of many details not given by the load-frequency curves of Figures 7 and 8, but on file at the Talbot laboratory, the following statements appear justified:

1 Under heavily loaded freight cars (coal, ore, etc.), wheel loads equal to or greater than 40,000 lb occurred on

an average in these tests once for each 1000 wheel loads passing over a given point in the rail.[12] At some points along the rail, the frequency of 40,000-lb wheel loads was three times as great as the average.

2 For less heavily loaded cars the frequency of 40,000-lb wheel loads was less than for the heavier loads.

3 High dynamic wheel loads may be caused by flat spots on wheels, out-of-round wheels, lack of concentricity of axle and rim of wheel, and non-uniformity of rail support.

4 From these field tests it seems that, in the speed ranges of trains below 25 mph, flat spots on wheels are very prominent as a cause of high wheel loads. In the range of 40 to 50 mph, hard spots in the rail support seem prominent, and in the range of 60 mph and above, out-of-round wheels, unbalance in counterweights, and abnormally large play between rail and tie (that is, lack of uniformity of rail support) loom up as important factors. These speed ranges probably will not be the same for locomotive drivers as for freight car wheels, but adequate data on which to base a quantitative statement are not available at this time.

[12] Tests of the ratio of flexural strain to flexural load were made by Dr. R. N. Arnold in the Talbot laboratory, University of Illinois. He applied load rapidly by means of a weight falling from various heights and striking at mid-span a rail supported head up as a single beam. To the tension side (base) were soldered a series of DeForest scratch strain gages which gave a record of strain variation along the base. From this the load applied could be determined with a fair degree of accuracy. The ratio of load to maximum base stress was found to be higher—in some cases 100 per cent or more—than the ratio of load to base stress under static load. This was due to the resistance to sudden bending offered by the inertia of the rail.

This result indicates that, since the curves shown in Figures 7 and 8 were determined on the basis of ratio of load to base stress as given by analysis for a static load, the wheel loads shown in those figures may be somewhat too low. However, the rapidity of load application to a rail resting on ties and ballast is probably considerably less than is the case with Dr. Arnold's stiffly supported test beam.—Editor's note.

2

STABILITY OF RESIDUAL FUEL OILS[13]

I

SUMMARY

1 Residual fuel oils are colloidal solutions in which asphaltenes are dissolved and dispersed in oil. An equilibrium exists between the dissolved and dispersed asphaltenes which is affected by several factors, such as the solvent properties of the oil, the amount and kind of protective material in the oil, the character of the asphaltenes, and the sensitivity of the asphaltenes to external factors such as heat. The stability of the fuel depends upon the effect of these factors in the equilibrium.

2 Two kinds of instability in our fuel oils were studied: the formation of suspended sediment in blends and the formation of deposits on the heating surfaces of oil preheaters. Most of the customer complaints about Special No. 3 Industrial Fuel have been due to sediment formation. Suspended sediment leads to operating troubles such as fréquent clogging of strainers and deposits on burner parts. These deposits interfere with efficient combustion of the fuel. Preheater deposits retard heat transfer, which reduces capacity and interferes with oil atomization.

3 A number of the tests described in the literature as measures of fuel oil stability were applied to our fuel oils. Of these tests, the ASTM centrifuge test for B.S. & W. was found to be a valid measure of suspended sediment, and the Batchelder Heater Coating Index test was accepted as a measure of the tendency of an oil to form heater deposits.

4 Whiting residual fuel oils are made from cracked tar produced at 369 and 370 Combination Units and at the Continuous Pressure Stills. The tar is cut back with C.P.S. blending oil to produce the light residual fuels. The amount of sediment in the blended residual fuels depends on the source of the tar and the paraffinicity of the blending oil.

5 A large number of tars from 369 and 370 Units were tested for their ability to give sediment-stable blended fuels. Those which give stable blends are termed stable tars. With only a few exceptions, the tars from 370 Unit were stable,

[13] Report prepared for the Whiting Laboratory, Research Department, Standard Oil Company (Indiana), by W. A. Proell.

whether obtained under coking or under vis-breaking operation. About one half of the 369 tar samples were unstable. Only a few tars from the C.P.S. units were tested; these were stable. No satisfactory correlation was found between operating conditions on the units and stability of the tar.

6 With unstable tars, the sediment content of blends reaches a maximum value in dilutions containing 70%-90% blending oil. This range includes two plant products: Stanolex A and Special No. 3 Industrial Fuel. Sediment-stable tars give blends which do not show this maximum.

7 The behavior of tars upon dilution with blending oil has been interpreted by a theory of critical dilution. The theory has proven useful in the practical application of laboratory results.

8 Blending oil paraffinicity is a fundamental factor in making sediment-stable fuels. Paraffinic blending oils, of U.O.P. characterization factor 11.20 or higher, cause sediment formation in blends with normally stable tars. Conversely, highly cyclic blending oils reduce the formation of sediment when they are used with normally unstable tars. The U.O.P. factor of C.P.S. blending oil is usually below 11.20 except when L.P. gas oil is used in the Auto Tar Plants. By diverting L.P. gas oil to other uses, Auto Tar Plant blending oil is produced which has a satisfactory paraffinicity for use with 370 tar.

9 Stabilizers for improving residual fuels were investigated. Asphalts derived from reduced crude, such as propane asphalt, are effective in concentrations of 3% to 5%. Aluminum and iron soap stabilizers were developed which give efficient protection in concentrations of 0.1%. A typical stabilizer of the latter type contains 50% aluminum naphthenate and 50% ethylene diamine oleate.

10 Heater deposit stability was not involved in the complaints on our fuels. However, it is an important characteristic of heavy fuel oils for such uses as U.S. Naval service since it affects steaming capacity. Heater deposit stability does not correlate with sediment stability. They are separate problems. The Batchelder Heater Coating Index test indicates that fuels derived from 369 tar give moderately high heater deposits, while our other fuels are low in such deposits.

11 Stabilizers were developed for improving the heater deposit stability of unstable fuels. The aluminum soaps

which are effective as sediment stabilizers are also effective as heater deposit retarders.

12 The most economical and practical procedure for producing fuel oils which are stable both as to sediment and heater deposits is to select stable tars and to control blending oil paraffinicity. However, if need should ever arise, our less satisfactory 369 tars can be stabilized against both sediment and heater deposits at relatively low costs, through the use of stabilizers developed during this research program.

13 In order to facilitate the selection of stable tars for refinery use, a rapid Standard Stability Test was developed. This test uses the sediment content of a standard blend, which has aged four hours, as a measure of the sediment stability of the tar. The standard blend is made of 20% of the tar being tested and 80% of blending oil of U.O.P. paraffinicity = 11.20. Tars which give 0.4% or less sediment by this test are stable. The test is a combination of the severest blending conditions which the tar is likely to meet in plant use.

14 Through cooperation with the Manufacturing Department, the information obtained from the laboratory work was applied to the production of Special No. 3 Industrial Fuel and Stanolex A during the winter of 1939-1940. This resulted in material improvement in the quality of these fuels. The B.S. & W. on shipments has been consistently around 0.2% with very few samples above this figure. There were no complaints on sediment during the last winter (1939-1940). As a result of the success of this program, the B.S. & W. specification on Special No. 3 Industrial Fuel and Stanolex A has been lowered to 0.5% maximum.

II

INTRODUCTION

Laboratory work on our residual fuel oils was started because of a series of complaints from customers, chiefly concerning our lighter blended products such as Special No. 3 Industrial Fuel. The variety and nature of the complaints indicated that instability of the fuel was responsible for many of them.

Instability manifests itself under service conditions in two general ways: as suspended sediment in the fuel and as adherent deposits in oil preheaters. Suspended sediment col-

lects in parts of burner systems and results in handling and burning difficulties. Heater deposits retard heat transfer, which reduces capacity and affects atomization of the oil.

Practically all of the complaints were related to the sediment type of instability, and they were often based on analytical test for the oil (B.S. & W. content) rather than on actual service difficulty. The research work on residual fuel oils was therefore primarily concerned with sediment stability, since improvement in sediment stability should improve the service performance of our oils as well as improve their analytical characteristics. Heater deposit stability is of concern to those who burn fuel oil in critical installations and in marine service, particularly the United States Navy; this type of stability thus has interest also.

Present oil inspection tests afford no certain or general criteria for determining fuel oil instability. The laboratory program was accordingly concerned with (1) developing methods for determining instability, (2) fixing standards of stability, (3) evolving a useful theory of fuel oil stability, and (4) applying the results to plant products so as to secure consistently stable residual fuels.

III

COLLOIDAL NATURE OF RESIDUAL FUEL OILS

Residual fuel oils are known to be dispersions of asphaltenes in oil. The dispersed asphaltenes are stabilized against flocculation by resins dissolved in the oil. Our research has shown that an equilibrium is present in which the asphaltenes distribute themselves between four states: solution, colloidal dispersion, suspension, and precipitated sediment. Seven factors control this equilibrium and determine the state which will contain most of the asphaltenes. These factors are:

(1) Solvent properties of the liquid phase
(2) Protective agents in the fuel
(3) Character of the solid phase
(4) Sensitivity of the system to external factors
(5) Electrical charge in the colloid
(6) Surface tension of the liquid phase
(7) Presence of gel structure

A theoretical study of the influence of these factors has been made and is, in part, available in conference reports.

(1, 2) From a practical viewpoint the first four are the important factors in fuel oil stability.

The solvent properties of an oil depend on its content of aromatic and naphthenic hydrocarbons. The aromatics are excellent solvents for asphaltenes, the naphthenes are fair, olefins are poor, and the paraffins will dissolve almost no asphaltenes. An average sample of No. 5 Industrial Fuel Oil from Whiting contains about 80% of oil and 20% of asphaltenes and resins. It is evident that variations in the aromatic content of the oil phase of this fuel will greatly affect the amount of asphaltenes which will dissolve in the oil. The solvent properties of an oil are conveniently measured by its paraffinicity as determined by the U.O.P. (Watson) characterization factor. Solvent power is particularly important in the blending of low viscosity residual fuels, where large amounts of blending oil are added to the fuel oil. If a paraffinic blending oil is used, large amounts of dissolved asphaltenes may be thrown into the colloidal state and may flocculate to give visible rapid sediment formation.

Solvency also changes the distribution of asphaltenes between the colloidal and the suspended states. A change in solvent power of the oil phase alters the efficiency of the protective resins. As is discussed in other reports (1, 2), the colloidally dispersed asphaltenes are prevented from flocculation by a mantle of adsorbed resins and low molecular weight asphaltenes which covers each asphaltene micelle. In a high solvency oil, these mantles are solvated and are readily wetted by the oil so that two adjacent asphaltene micelles do not adhere to each other on contact. In a paraffinic oil the protective mantles are nonsolvated by the oil and are therefore not oil-wetted. In this case surface tension causes the coalescence of adjacent asphaltene micelles into larger and larger micelles which may reach noncolloidal dimensions. The high solvency oil accordingly favors increased sediment stability.

The role of resins and low molecular weight asphaltenes is extremely important, since they form the essential protective mantles which keep the bulk of asphaltic material of a residual fuel in the colloidal state. The efficiency of resins and low molecular weight asphaltenes in mantles depends in part upon their inherent characteristics, especially such properties as solubility in oil, ease of solvation, and adsorbability upon asphalt micelles. The protective mantle necessary in a good fuel is probably quite thin and may be only a few

molecules thick. A mantle may be obtained with non-resinous materials, such as metal soaps. In ordinary fuels the protective mantle is made of hydrocarbon material alone.

The major characteristics of the dispersed asphaltenes which affect stability are asphaltene solubility, the amount present in fuel, and the adsorptive capacity of asphaltenes for protective resins.

A property of importance is the sensitivity of the residual fuel to external factors such as chemicals, oxidation, light, or heat. This property is due to the relation between many of the factors discussed above and their susceptibility to alteration by outside influences. A fuel oil which is sensitive to heat and metallic surfaces is one which will give trouble with heater deposits.

IV

METHODS OF MEASURING INSTABILITY

The sediment stability of residual fuel oils is measured by the sediment content of the oils. Microscopic examination of fuel oil known to give service difficulty shows the oil to contain abundant coarsely flocculent particles which have been found to be asphaltic flocs, or sediment, in residual fuels:

(1) B.S. & W. by centrifuge—A.S.T.M. Test D96-35
(2) Sediment by extraction—A.S.T.M. Test D473-38T
(3) Microscopic examination and count
(4) Sediment by hot filtration

Methods (3) and (4) are direct methods which in an ideal case would give absolute measurement of sediment content. The four methods were tested on various oil samples to compare results. It was found that a general agreement exists between all methods, but that no exact relation is present. Microscopic count of suspended sediment is theoretically most reliable (except for possible sediment whose refractive index is the same as the index for the oil) and should therefore be the method used as a criterion of all other methods. Unfortunately, microscopic count is a very difficult procedure. In comparing methods, an approximate method was used for microscopic count in which the density of sediment was estimated on an arbitrary scale. A comparison of results obtained using this microscopic examination and the standard B.S. & W. test is shown by the following table:

Microscopic Examination		Average B.S. & W.
0 (no flocs)	=	0.08%
1 (trace to very few flocs)	=	0.09%
2 (few flocs)	=	0.14%
3 (moderate)	=	0.17%
4 (considerable)	=	0.29%
5 (very much)	=	0.50%
6 (extremely high)	=	1.12%

Since this table is based on a series of sixty samples of oils, the validity of the B.S. & W. method as a comparative measurement of sediment content is indicated.

The sediment by hot filtration test was made according to the method of Hulse and Thwaites. (3) Fuel oil is maintained at 210° F. in a steam-jacketed funnel and is filtered through an asbestos mat with the aid of vacuum. The residue on the mat is washed with naphtha and weighed. Some comparative results are:

Oil Sample	B.S. & W.	Sediment by Hot Filtration
No. 5 Fuel Oil, Sample A	0.2%	0.81%
No. 5 Fuel Oil, Sample B	0.2%	0.82%
No. 3 Fuel Oil, Sample A	3.6%	1.52%
No. 3 Fuel Oil, Sample B	3.8%	1.55%
Spec. No. 3 Fuel, Sample A	5.6%	1.0%
Spec. No. 3 Fuel, Sample B	5.6%	1.35%
Spec. No. 3 Fuel, Sample C	1.8%	0.27%
Spec. No. 3 Fuel, Sample D	0.5%	0.09%

It is noticed here that for any given grade of oil, the B.S. & W. test and the sediment by hot filtration test give proportional results, but such proportionality fails when different grades are compared. This peculiarity is due to a defect in the hot filtration test. The hot filtration test uses a vacuum to pull the hot oil sample through an asbestos mat. When this operation is complete, the asbestos mat still contains considerable oil. When the naphtha wash is applied to the mat, much of the asphaltenes dissolved in the oil adhering to the mat are precipitated in the mat. No washing with naphtha will remove those, so that the increase in weight in the mat is not only due to the sediment filtered out but is also due to

the asphalt precipitated in the body of the mat. This error is especially high with the high viscosity fuels, such as No. 5 Industrial, which are so viscous that large amounts are retained by the mat, and which are so rich in asphaltenes as to give unusually heavy deposits of asphalt in the mat. The above table shows clearly that in the case of heavy No. 5 Fuel, sediment by hot filtration is much higher than sediment by B.S. & W., while in the low viscosity fuels, such as Special No. 3, B.S. & W. gives higher values. If these errors are discounted, it would seem that once again B.S. & W. gives results which are valid when judged by an absolute (although inaccurate) method.

Little work was done with the sediment by extraction test because it is laborious and involves theoretical objections (solvent effect of benzol, heat, uncertain dilution, etc) which make it undesirable for exact work.

As a result of the above considerations, the B.S. & W. test was adopted for this work as a measure of sediment content, and all further data (unless otherwise indicated) show sediment content as determined by the B.S. & W. test. The test appears valid, and is accurate, reproducible, rapid, and convenient. It measures the volume per cent of suspended sediment which is centrifuged out of a 50% sample—50% benzene blend at 1500 rpm. The test also measures suspended water as well as sediment, but throughout this work water free fuels were used so that the test measured suspended sediment only.

The heater deposit stability of fuel oils has been the subject of several published studies. Batchelder of Standard Oil of California and the U.S. Naval Boiler Laboratory have developed tests for the measurement of this type of stability. The Batchelder test, described in more detail in Section V-D, measures the amount of benzene insoluble material which deposits on a polished steel surface maintained at 335° F. and immersed in the oil sample for 96 hours. The Batchelder test was used extensively in our work, and according to published data it is reliable and accurate. The Naval Boiler Laboratory has a test similar to Batchelder's, but this test was not tried by our laboratory. It also has developed an oil oxidation test which is supposed to correlate well with actual performance of the oil in service preheaters. This latter test was tried out and it gave results which agreed well with Batchelder's test, but since the latter is more convenient it has generally been used in our work.

The measurement of fuel oil stability is therefore studied chiefly by two tests: the B.S. & W. determination and the heater coating index test of Batchelder. These two respectively evaluate sediment stability and heater deposit stability.

VII[14]

APPLICATION OF RESULTS TO PLANT OPERATION

At the time the residual fuel research program was begun, the refinery had considerable difficulty in preparing Special No. 3 Industrial Fuel and Stanolex A of suitably low sediment content and complaints were frequent. Cooperation between the laboratory and the refinery resulted in the application of some of the research program's results to plant operation. This cooperation improved the fuel oils markedly.

Prior to June, 1939, it was the practice to use either 369 or 370 tar in preparing blended fuels. Whichever stock was most convenient was used. By the fall of 1939, this practice was altered and 370 tar was used consistently. During the winter of 1939 the diversion of some L.P. gas oil from the Auto Tar Plants was begun. By February, 1940, L.P. gas oil was generally diverted elsewhere when light blending oil was being made at the Auto Tar Plants.

The results of the program are shown by a comparison of sediment contents of fuel oils produced before and after the program. Table No. 6 gives B.S. & W. inspections on the shipping tanks of fuel oil; and is taken in part from the Light Oils Department inspection records.

TABLE NO 6

Stanolex A

Period	Average B.S.&W.	Maximum B.S.&W.	No. of Unstable Samples (Above 0.4% B. S. & W.)	Total No. of Samples
Nov. 1938 to June 1939	0.4%	2.0%	13	50
Oct. 1939 to Mar. 1940	0.17%	0.5%	3	70
Mar. 1940 to Sept. 15, 1940	0.13%	0.2%*	0	26

[14] Sections V and VI of this report have been omitted.

Special No. 3 Industrial Fuel

Period	Average B.S.&W.	Maximum B.S.&W.	No. of Unstable Samples (Above 0.4% B. S. & W.)	Total No. of Samples
Nov. 1938 to June 1939	0.27%	0.8%	7	43
Oct. 1939 to Mar. 1940	0.23%	0.55%	7	79
Mar. 1940 to Sept. 15, 1940	0.14%	0.3%	0	14

(*Excludes one sample grossly contaminated with water.)

The results show clearly that the application of information from the laboratory has markedly improved the sediment content of our residual fuel oils. This improvement has much reduced the number of complaints about our fuels. Since the new program has been in effect there have been no sediment complaints on our residual fuels, and the few other complaints which were received were concerned with operating or equipment factors.

One other result of this fuel improvement has been the reduction of the B. S. & W. specification for Special No. 3 Fuel and Stanolex A from 1.0% maximum to 0.5% maximum. The new maximum of 0.5% will eliminate shipment of unstable blends and insure more uniform quality. There should be no difficulty in meeting the new specification if the control program is followed.

VIII

FUTURE PRODUCTION OF RESIDUAL FUELS

The cooperation of plant and laboratory has led to considerable improvements in blending fuel oils, and the fuel oil quality at present is very satisfactory. Nevertheless, the present system is not "ironclad," and it is to be predicted that at rare intervals a batch of unstable 370 tar will be used in blending. The present B. S. & W. specification will insure the rejection of blends made from such stock, so that no consumer difficulties will occur. The only way to avoid these "bad" batches of tar is to put into effect the control program discussed earlier, which is designed to eliminate all unstable blends. Until such

> measures are taken, the production of stable fuels will always contain an element of chance. The application of the principles developed in this report should, however, always lead to eventual correction of operating problems and to the production of highly acceptable residual fuel oils.
>
> BIBLIOGRAPHY[15]

Exercises

A Write a daily formal periodic report on your activities in shop, laboratory, field, office.

B Write a weekly periodic report on a topic similar to that of A.

C Write an annual periodic report to the stockholders of a corporation, to the members of a society or organization in which you hold an official position, or to the president of a company, setting forth in as great detail as possible and in a carefully organized document the activities of the period just ended.

D Write a weekly progress report, showing progress of work

1 Day by day for the week
2 According to different aspects of work covered

E Write a progress report

1 On a piece of research work
2 On extended construction work

F Write a final progress report, presenting from the point of view of the engineer in charge the concluding aspects of the work and arrangements for such items as dismissing men, shipping machinery, closing accounts, etc.

G Write an examination report with conclusions or recommendations or both on one of the following:

1 Advisability of using skilled or unskilled labor in a given case
2 Approaches to railroad crossings in town and vicinity and proposed plans of eliminating grade crossings

[15] For the purpose of this *Manual,* the Bibliography, so vital a part of this kind of report to technical investigators, does not seem to be necessary and is therefore omitted.

3 A proposed wiring system for some college building
4 Drainage of college grounds
5 Rearrangement of shop machinery
6 Proposed method of ash and coal handling
7 Advisability of installing automatic stokers
8 Proposed ventilating system for a mine
9 The feasibility of adopting certain plans as to (1) installation of machinery, (2) wage system, (3) methods of manufacture or management
10 The advisability of building, establishing, changing, abandoning, as the case may be, a bridge, a factory, a business, a laboratory
11 Application of a chemical process to an industrial operation

H Write a short laboratory report on an experiment or test.

I Write an examination report, without recommendations, on

1 An inspection of (a) a manufacturing plant, or (b) an engineering building, or (c) a laboratory, or (d) a power plant, or (e) a sewage-disposal plant, or (f) a water-supply system
2 One of the following: (a) repair work, (b) pieces of apparatus and appliances needed in a certain test, (c) existing labor conditions in a certain locality, (d) geological conditions in a certain locality

J Write a report on a problem suggested by the following:

The Woolley Cotton Mills, East Camden, New Hampshire, desire advice upon the selection of a site for a branch plant to be located in the South. After considerable correspondence and several trips through the South, the management has centered upon Gosport, North Carolina. A complete report is now required, showing the following data in detail: location and size of town, description of site, railroads, water, water power, electric power, labor supply, probable labor turnover through competition, wages, labor legislation, taxes, basis of assessment, supply of raw cotton locally available, price and freight rates on coal, community support, distribution of product, housing conditions, sewerage system, layout of mill village, fire protection, general type of mill buildings, management, summary of advantages and disadvantages, recommendations. Detailed description of the mill buildings is not to be included in this report.

K Write a complete laboratory research report.

CHAPTER 6

Writing for Technical Journals

The scope of technical journalism is broad. It comprises editorials; abstracts and summaries; definitions; explanations of new inventions and processes; book reviews; news notes; letters to editors; descriptive articles; and technical expositions of involved processes, manufacturing developments, engineering undertakings; and, for the professional writer, the composition of advertising pages. To this particular field, most engineers, soon or late in their professional life, make frequent contributions. To a smaller group, writing for technical journals is a professional occupation which entails all the duties of an editorial staff.

The title of this chapter may be thought of as more comprehensive in scope than is suggested by the actual words "technical journals." Within its bounds would certainly be included, as our specimens indicate, public addresses (frequently reproduced, as we know, in journals) and the kind of expository writing which appears in engineering textbooks. Definitions are also included here, because the processes involved in framing a brief or an amplified definition confront the writer in connection with one or another of the kinds of writing which appear in technical journals.

The discussion and the specimens in this chapter are designed to offer material to the student which he can best use and best profit by in the writing for practice which he will do at one time or another in his college course. Supplementing the general discussion of technical writing in Chapter 1 and Chapter 2 are the specific discussions which follow here. The specimens are of course not intended to be all-inclusive. They do not represent all branches of engineering. It is hoped, however, that all of them are general enough to be readily understandable to any group of upper-class engineers.

Editorials

The specimens of editorials printed on pages 324-327 are illustrative of the best editorial writing of reputable technical journals. In these editorials writers are concerned primarily not with presenting facts or giving information, but with a discussion of known facts or of theories or ideas. They assume that their readers have a certain amount of knowledge on the subject. The problem of presentation is, therefore, greatly simplified.

A one-paragraph editorial requires little detailed planning. The writer realizes that he is expected to comment briefly, lucidly, and convincingly on a specific subject, and always with one definite, limited purpose in mind. The main point or the general thought of his paragraph is often given in the first sentence. There is no space for any but the briefest explanation of the reason, scope, or importance of the discussion. The discussion then advances logically from sentence to sentence until the end, where a crisp statement may be desirable for emphasis.

In editorials of two or more paragraphs, more planning is necessary. The writer must determine what definite aspects of the subject he will consider. With his plan in mind or on paper, he must decide on the nature of his beginning, the order of treatment, and the most effective conclusion. Some indication at the outset of the main points of the discussion is sometimes desirable. Transition words or phrases will mark clearly the passing over from one division of the subject to the other and the relation of each division to the main subject. No formal conclusion will be necessary unless the editorial is unusually long.

The editorial writer's opinions must be presented in clear, precise, vigorous language. Sluggish, verbose phrasing makes the reader apathetic; sharp, clear-cut statements stimulate him.

EDITORIALS

1

FROM HIGHWAYS TO AIRPORTS[1]

Highway maintenance forces in areas not subject to possible emergency demand are a potential source for airport construction

[1] *Engineering News-Record*, Vol. 128, No. 21 (May 21, 1942), p. 60. This editorial, and the following one, ten years apart in date, illustrate admirably one-paragraph editorials, a kind of writing practiced for so long and so effectively by the editors of the *Engineering News-Record*.

and maintenance crews. Operating on inadequate budgets for years, these men have learned to get the most from a little and they are skilled in making machines last far beyond their usual span of life. Not only are they familiar with drainage- and snow-disposal problems, but they have also developed special abilities in patching and maintaining paved surfaces. Limitations on use of materials for highway maintenance soon may make it necessary for many of these skilled workers to seek other jobs. This potential pool of men and equipment profitably could be employed to promote the war effort. Possibly all airport maintenance could be turned over to such crews who, over the years, have developed a "best" method of working under local conditions. Such a procedure might be especially helpful in connection with new airports where difficulty exists in assembling experienced crews and necessary equipment. Highway maintenance men who long have been a factor in aiding the mail carrier "to complete his appointed rounds" are in a position where they can contribute their bit to "keep 'em flying."

2

SOUND CONCRETE[2]

Good concrete may be assured by the conscientious application of a few simple rules. This fact becomes increasingly evident as surveys are completed of concrete structures in service over a period of years. Those structures upon which these rules—largely matters of common sense and not intricate formula—have not been violated show up exceedingly well. The famous Tunkhannock viaduct of the Lackawanna Railroad, the largest concrete railroad bridge in the world, has recently undergone a thorough inspection after seventeen years of service. Wind-blown water had caused some discoloration, and imperfect expansion facilities in the parapet resulted in some cracking, but otherwise the 165,000 cu yd of concrete in its ten 180-ft spans is in perfect condition inside and out. Searching for some explanation of this sound condition, one finds only that the mix was not uncommonly rich (1:2:4 for the floor and 1:3:5 for the remainder), that the aggregates were clean and sound, that the mix was as dry as it could conveniently be placed, that thorough mixing was mandatory, and that every placement was carefully rodded and tamped. Quite similar factors were held to account for the sound concrete in structures examined several years ago by a committee of the American Concrete Institute. Conversely, the poor quality of other concrete in most cases was attributed to violation of one or more of the above-mentioned

[2] *Engineering News-Record*, Vol. 108, No. 2 (1932), p. 43

simple rules. These inspections of structures in service are providing the concrete art with a much needed background. They should drive home the fact that, regardless of the refinements in strength and density to be obtained through the application of modern discoveries in aggregate proportioning and mix design, the production of durable concrete still rests on a few simple rules, conscientiously and sensibly applied.

3

WATCH STYRENE DEVELOPMENT[3]

Styrene, a benzine type of derivative of coal tar, with a remarkably favorable combination of electrical, mechanical, and thermal properties, bids fair to play an important role in cable development. The British have steadily improved the technique of applying it to cable joints, and cable manufacturers here have been following the movement, in some cases with active experimentation, and a few of the larger utilities have been trying it out cautiously.

The product is available here from several sources. It has other uses than for cable, and once again the cable art, which relies very largely for its materials upon the progress of non-cable uses, can hope to profit by the prospective reduction from the present high cost of the material. Meanwhile, the stability and purity of the liquid monomeric form will undoubtedly improve, as will the rate at which the transition to the solid polymer can be made to take place.

Delaying influences seem not to have deterred the British; in fact, it has been stated that the over-all cost of a completed joint is not only competitive but that the procedure is fast enough to meet the requirements of speed and simplicity. A cartridge of plasticized material is made up at the factory and its contents are forced into the joint to replace the liquid form with which the joint is first filled, and the whole joint can be done in about two hours ready for immediate energizing.

On the whole, the insoluble filling compounds used here in making up joints and terminals while admittedly not a perfect answer have steadily improved joint performance, and there is little likelihood of any stampede to such an alternative technique. Nevertheless the sympathetic reception of the British experience by American cable engineers indicates that there is a degree of interest which can be expected to expand. This is the procedure which evolved from an effort to perfect a technique which could produce a good joint quickly without heat application and with less careful workmanship—all measures that are dictated by war conditions

[3] *Electrical World*, Vol. 115, No. 20 (May 17, 1941), p. 61

Prior efforts to pour in liquid styrene and wait for the polymerization were of dubious success, even after injecting inhibitors and stabilizers to control the transition to solid state. But the cartridge is filled with styrene which is better than 95 per cent polymerized —well along toward full solidification—yet plastic enough to be extrudable and nook-and-cranny-filling.

4

CUTOFF WALLS OF ASPHALT[4]

The first use of what may well be the forerunner of important developments in dam construction—asphalt for cutoff walls—is reported in this issue in more detail than has been available in the past. This application was in one abutment of the dam for the Claytor hydro-electric project near Radford, Va., completed late in 1940, where a hot sand-asphalt mix was used to form a cutoff wall across a wide zone of bad ground.

The possibilities of this method for correction of similar bad underground conditions at other dams, or even for making cutoff walls in earth or rockfill dams, appear to be large. As a construction material, the hot sand-asphalt mix has many advantages. It is easily prepared and handled, and, because of its ability to weld itself into a homogenous mass, construction joints are no problem. From the design angle, the fact that an asphalt mix maintains a considerable amount of flexibility for an indefinite period gives assurance that the wall will adjust itself to settlement or other minor movements without rupture. In fact, it appears possible that this material might be used to form a watertight diaphragm in a rock or earthfill dam and that by installing heating pipes in the sand-asphalt mix as it is placed, sufficient fluidity could be maintained to assure complete adjustment to settlement during a long period following construction.

Hot asphalt has been used in the past for sealing construction joints in dams. It also was used to grout the foundations of Hales Bar Dam, but that application did not prove to be permanently successful because a complete asphalt diaphragm was not created and the soft rock that was left ultimately dissolved out. The method used at the Claytor plant promises to be more successful.

Abstracts and Summaries

The terms "abstract" and "summary" are often used interchangeably to indicate a brief synopsis or condensation of a

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[4] *Engineering News-Record*, Vol. 128, No. 13 (March 26, 1942), p. 47. See article *Asphalt Cutoff Wall at Claytor Dam*, p. 363

longer piece of writing. If there is a technical difference between the two forms, it may be said to be as follows: a typical abstract uses in the main the exact language or an approach to the exact language of the original article or book; a typical summary gives in the main the ideas or facts of the original in the words of the summarizer or reviewer. The summarizer or abstractor may also be the original writer. For an article of considerable length, the original writer is often asked to prepare a brief statement of the contents, which in technical journals is frequently placed at the beginning of the printed article. Such a piece of writing is also designated as a "synopsis."

The subject of abstracts is discussed at length by E. J. Crane in an article entitled "In the Abstract."[5] As will be seen from the following brief synopsis of his discussion, what Mr. Crane says about the abstract would seem to apply equally well to the summary:

> There are two kinds of abstracts—(1) informational, which give the more important results of a study; and (2) descriptive abstracts, which refer the reader to the full paper for all information beyond a statement of the scope of the work reported. Good abstracts are usually mixtures of the two kinds. A complete abstract indicates fully the scope of the paper and reproduces with adequate precision the most important results and conclusions. The length cannot be standardized. A single brief sentence may provide a wholly adequate abstract of a long and important paper, whereas many sentences may be required for the proper reporting of a brief and relatively less important paper. The telegraphic style sacrifices clearness and ease in reading for brevity. Abstracts should be made up of complete sentences. Scientific exactness is essential.
>
> A common mistake made by inexperienced abstractors is to begin an abstract with a sentence which merely repeats the information given in the title. In the matter of paragraphing, a middle course should be followed between the extremes of a lengthy abstract in one paragraph and of an abstract in which every sentence is set off in a paragraph by itself.

Using then the convenient term "summary" to denote such condensed statements, we may say that they may be in the form of: (1) An expository paragraph or a succession of short paragraphs presenting what may be regarded as a summarizing discussion. See, for example,

[5] *Industrial and Engineering Chemistry*, News Edition (June 20, 1938), p. 353

(a) "summaries" in the Editorial Staff Reports in *Chemical and Metallurgical Engineering*, November, 1941, pp. 88-101, which are not more than 100 words in length for articles of from two to four pages

(b) "abstracts" in *Chemical Abstracts*, one brief specimen appearing in this book on p. 330

(c) the usually more lengthy abstracts of *Highway Research Abstracts*, published by the Highway Research Board, National Research Council or the likewise lengthy abstracts in the *Library Bulletin of Abstracts*, published by the Research Laboratories of the Universal Oil Products Company

(d) "synopses" of papers in the *Proceedings of the American Society of Civil Engineers*, June, 1942 (e.g., the 2-page synopsis of the 38-page paper on Liner-Plate Tunnels, or the 1½-page synopsis of the 22-page paper on Earth Pressure on Tunnels, or the 100-word synopsis of the 16-page paper on Classification of Irrigable Lands)

(e) the brief summaries which appear at the beginning of several articles in this chapter. (See for example *Asphalt Cutoff Wall at Claytor Dam*, p. 363, or *Drawing Dies for Airframe Stampings*, p. 359.)

(2) A succession of single-statement paragraphs, in which each fact is given for its relatively independent importance. See, for example, summaries of articles in *Industrial and Engineering Chemistry*, Analytical Edition, June, 1942.

(3) A summarizing review, in which are given the actual words of an article, to which are attached comments or merely directive phrases from the critic or reviewer. See, for instance, book reviews of technical publications.

Summaries proper appear as brief independent expositions of the content of long articles, as concise introductions or conclusions in long reports, as prefatory statements to lengthy articles, or as concluding paragraphs of scientific or technical articles.

Good summaries are characterized by completeness of information, conciseness of statement, and clearness of reference to the original articles. They demand of the writer the ability to separate the main ideas or important points from the secondary or unimportant, to express these main points with the greatest economy in words, and to present the details of the exposition in coherent order.

ABSTRACTS AND SUMMARIES

1

Thin oxide films on iron. E. A. Gulbransen. *Trans. Electrochem. Soc.* 81, 11 pp. (preprint) (1942).[6]—A vacuum microbalance technique for the study of chem. reactions occurring on metallic surfaces is described. Preliminary curves are presented for the oxidation of pure electrolytic Fe from 25° to 400° and at various pressures of 0. Attempts are made to correlate the data with the various mechanisms proposed for oxidation reactions. A suggestion is made that the overall rate may be thought of as a sum of 3 individual rates: (1) a rapid initial rate; (2) an intermediate reaction which involves the log of the difference between an extrapolated parabolic law and the exptl. value as a function of time; and (3) a parabolic law which is found to hold above a certain temp. and film thickness. C. G. F.

2

Silica Removal by an Improved Magnesia Process. H. L. Tiger, *Trans. Amer. Soc. Mech. Engrs.*, 64, pp. 49-58; Disc., 58-63, Jan., 1942.[7]

Modern h.p. boilers with high feedwater make-up requirements frequently demand reduction of dissolved silica. A new magnesia process for silica removal has been developed, combining flexibility, simplicity, and economy. It can be applied to any type of water at any temperature; it can be carried out in conjunction with the usual precipitation water-softening process; and the increase in operating cost is small. Investigations were conducted to determine the influence of each of various factors on the final result, and data are presented on the effects of the following: Form of Mg used (whether precipitated ionic Mg or undissolved Mg compound), temperature, sludge-Mg concentration and agitation for sludge-water contact. The principles of increasing the Mg content, when required, by means of a novel sludge recycling process with a dissolver are described. A method of using cheap dolomitic lime as a low-cost source of Mg is also presented. The process lends itself advantageously to a modified Spaulding precipitator type of construction at either low or high temperature, to be followed by suitable treatment with carbonaceous-ion exchangers, when required, for complete removal of residual hardness and reduction of alkalinity to any predetermined figure.

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[6] *Chemical Abstracts,* Vol. 36, No. 10 (May 20, 1942), col. 2824

[7] *Electrical Engineering Abstracts* (Science Abstracts—Section B), Vol. 45, No. 532 (April, 1942), p. 63

3

Vapor Condensers for Cooling Organic Liquids. A. P. Colburn, L. L. Millar, and J. W. Westwater, University of Delaware.[8] Cooling organic liquids before discharging into storage tanks often prevents excessive loss in the displaced air, and in an attempt to encourage the practice of using vapor condensers to do this cooling. The authors conducted basic research on the use of vertical vapor-in-tube condensers, with the tubes long enough to accomplish the desired degree of sub-cooling.

The work was done on a single condensing tube, as this was the best means of obtaining the fundamental data for design purposes. A ⅞-inch outside diameter condensing tube, surrounded by a 1-inch inside diameter tube for the water coolant, was used. Spiral flow was assured by winding a 10-gage wire around the inside tube and forcing the outside tube over the filed down wire.

Results indicated that vapor temperatures of the organic materials condensed—acetone, isobutanol, and trichloroethylene—were steady down to a certain point, where they varied widely for about 6 inches of tube length, and then dropped steadily to the exit port. Interpretation is that the gases condensed in a very sharp zone.

The authors were able to suggest a design procedure on the basis of the data obtained. They recommended: estimation of the average condensate temperature at the end of the condensing section to break down the heat load to condensing and subcooling requirements; prediction of the separate film coefficients; selection of the proper mean temperature differences; and calculation of the tube length for each duty.

Definitions[9]

The purpose of a definition is to explain the significance of a word, a phrase, or an idea in terms that can be understood and that will make the meaning clear and unmistakable.

Definition proper. A definition proper or "logical" definition involves three main parts: the term, the class to which it belongs, and the feature which distinguishes it from others of this class.

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[8] *Chemical and Engineering News*, Vol. 20, No. 10 (May 25, 1942), pp. 663, 664

[9] The one discussion of Definitions in this book is presented in this chapter. Some teachers may prefer to treat this subject in connection with Words (Chapter 2), giving it a more ample treatment than would be suggested by the few specimens here printed and by the exercises at the end of the chapter.

DEFINITIONS PROPER

1 Work is the action of a force in displacing a resistance through a distance, and is measured by the product of the force multiplied by the distance moved in the direction of the force.

2 Power is the *rate* at which energy is expended or consumed.

3 The torque of an engine shaft, or other rotating element, is its turning moment, which is measured by the product of the force and the perpendicular distance from the axis of rotation to the line of action of the force.

4 A body is said to have kinetic energy when it has capacity for doing work through change in its velocity.[10]

Clear-cut technical definitions must observe certain cautions.

Writers should not dismiss a definition with nothing more than synonym. Such a definition is poor. In the first place, technical language has few synonyms. *Radiation* does not mean the same as *waves,* though the words are closely related in meaning; *machinery* has a significance different from *mechanism;* and *reservoir* is not the same as *tank.* Moreover, synonyms as definitions are deficient in clarity, since the synonym is usually as difficult as the word itself. To define the word *lexicon* by the closely synonymous *thesaurus* is unsatisfactory, since a person unacquainted with *lexicon* would hardly recognize *thesaurus.*

Writers should not use as definition another form of the word being defined. If a word needs defining, its etymological relatives probably need it, too; and the reader is forced to resort to the general definition in a dictionary, the very place he should not have to visit. *Substitute* is poorly defined as "material or article *substituted* for some other material or article." *Simplicity* is not rendered much clearer by the dictionary definition "quality or state of being *simple.*"

For the same reason, definitions should be given in as simple words as possible. A definition of *dehydration* as "the progressive and thorough desiccation of a substance or material by thermal, chemical, or physical processes" does not aid very much.

Formal definitions, especially those requiring several words, should preserve a balance between the words used in classification and those used in giving the differentiating qualities. To use *contrivance* as the class word, genus, in a definition of

[10] These four definitions are taken from W. N. Barnard et al., *Elements of Heat-Power Engineering,* third edition, Wiley, 1926, pp. 5, 6, and 11.

telescope is to leave entirely too much work for the differentia to perform. Even the word *instrument* is too inclusive. *Optical instrument* is more satisfactory, since it leaves only narrow restrictions for the differentia. On the other hand, it is poor defining that uses a class word so closely synonymous that it is interchangeable with the word being defined. Yet one sees frequently such overlapping as "An engine is a motor which, etc.," or "A motor is an engine which, etc."

Definitions should always be made with the realization that what is being defined is not a word, but is rather an object, concept, or quality. The definition should seek to portray the *idea* rather than merely to explain the *word*, which is, after all, only a symbol of the idea. A definition should set the extent, the limitations, the inclusions and the exclusions of the concept which is being defined. Merely to define a *word* is to make a product as lifeless as a photograph of a painting.

Expanded definition. An expanded definition involves amplifications, such as details of structure or use, analysis, examples, comparison or contrast. Several methods are used for the effective expansion of definitions, after the genus and basic differentia are given:

METHOD OF DISTINCTION. A most useful method is that of distinction. In this method, two or more words very nearly alike in general meaning are first defined according to the broad meaning common to all of them, and then separately distinguished as they vary from the common significance. Thus the words *dictionary, glossary, index, lexicon, thesaurus,* and *vocabulary* agree in that each is a list of words, usually alphabetically arranged and discussed or explained in some way. A *dictionary* is a list of all the common words in a language, each word defined according to its part of speech, and frequently according to its etymology, synonyms, and antonyms. A *glossary* is a list of unfamiliar words used in a particular book, frequently a book of instruction in a foreign language. An *index* is a list of words to indicate topics and subtopics discussed in a book. *Lexicon* is sometimes used synonymously with *dictionary,* but is more frequently a dictionary of Greek or Latin. *Thesaurus* is sometimes synonymous with *dictionary* but is more frequently limited to a listing of words treated according to the grouping

of their synonyms and near-synonyms. A *vocabulary* is a list of words, usually limited in number, defined as used in some brief discussion, as in a chapter or assignment in a text.

METHOD OF CONTRAST. Another method of definition is that of contrast. Such terms as *dynamic* and *inert, productive* and *barren, benevolence* and *malevolence, approval* and *opposition,* and the like agree only in that each word in the couple is related in some way to the same article or idea. Their further significance is completely opposite one to the other. Their proper definitions may thus be presented by an elaboration of the oppositeness of the words.

METHOD OF NEGATION. Closely allied to the method of contrast is the method of negation, the process of arriving at the meaning of a word by a series of statements about what it is not, after which, properly shorn of extraneous matter, the true meaning of the word is revealed. For example, the following definition of engineering arrives at its objective mostly through eliminating the possible but erroneous definitions: "Engineering is not merely the mathematical mind; it is not simply the dexterous hand; it is not just a means of making things, or of creating or directing energy; it is not only a manner of making a living or of accumulating wealth. It is rather a profession, a way of life and living, intimately bound up with man's relation to man, and with the nobler impulses of all humanity."

METHOD OF DERIVATION. Another method of giving the boundaries of a word is that of derivation. Many engineering words are perfectly clear in meaning as soon as the etymological basis of the word is learned. The word *synchronism,* for example, probably means nothing to the uninitiated. As soon as the root meaning, *together-time,* is clear, however, the whole word is explained as well as by a long and complicated definition. The same is true of *thermodynamics* (*heat-power*), the science of relationship between heat and motion; *hypodermic* (*under-skin*), a treatment administered directly through the skin; and *retrospection* (*backward-looking*), recollection, an examination of past events.

METHODS OF EXAMPLE AND DESCRIPTION. Words may also be defined in whole or in part by example or by description.

Though neither of these methods is often used for an entire definition, both are of value in amplifying a formal presentation of genus and differentia. Example and description are likewise the connecting link between formal and informal definition; however, informal definition, colored by emotion, taste, or individual bias, has little place in technical writing. Example and description must therefore be used only guardedly and jointly with other methods.

EXPANDED DEFINITIONS

1

FACTOR OF SAFETY[11]

The ratio of the strength of a material to the maximum calculated stress in the material is known as the factor of safety. It is introduced to provide for the uncertainties mentioned in the preceding article.[12] Allowable working stresses are sometimes set by dividing the strength of the material by an appropriate factor of safety. The minimum factor of safety to be used in a given situation depends not only on the material, type of loading, and type of failure expected, but also upon the cost of replacement and possible damage to life or property in event of failure.

For a uniform ductile material designed against slip under steady loading, a factor of safety of 2 *with respect to the elastic strength,* or about 4 *with respect to the ultimate strength,* is often used in general construction. A brittle material which is subject to occasional impact as well as steady load may require a factor of safety of 20 *based on the ultimate strength.* The factor of safety for a less uniform material such as stone under an impact load may need to be 40 *with respect to the ultimate strength.*

2

GRAVEL[13]

Gravel consists of partly rounded and smooth fragments of rock ranging in size from fine sand to small boulders, with varying amounts of silt, clay, and other earthy material mixed with it. The portion of the material that will pass a No. 4 sieve, exclusive of the earthy material, is called *sand,* and the portion coarser than

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[11] This definition is taken from O'Rourke's *General Engineering Handbook,* McGraw-Hill, 1940, p. 146.
[12] Under "allowable stresses"
[13] O'Rourke, pp. 621, 622

sand is variously called *stone, pebbles,* or *gravel.* There are two common types of gravel, pit gravel and river or beach gravel. The pit gravel is in deposits left by the glacial streams or in moraines. The grading and quality of pit gravel are quite variable, a stratum or portion of the pit generally running high in fines or oversize materials, earthy material, clay balls, shale, iron oxide pebbles, and similar soft material. River or beach gravels are deposited in beds or near streams and along lake or sea beaches. The particles are more rounded than those in the pit gravels, and there is a deficiency of bonding material. By a screening, crushing, washing, or mixing process, it is generally possible to produce a gravel from local deposits which will meet the grading and quality requirements for the various classes of intermediate-type road construction.

3

THERMODYNAMICS[14]

The term *Thermodynamics* is often applied broadly to mean the science which deals with the relation between thermal and the many other forms of energy. Since these other forms may be mechanical, electrical, chemical, or biological, the subject is a most extensive and fundamental one. As limited to engineering, and as used in this text, thermodynamics is that branch of science which deals with processes whose only significant aspects are thermal and mechanical ones. In connection with it the properties of gases and vapors are investigated for the purpose of determining the energy transformations involved in heat engines, refrigerating machines, and gas compressors.

Thermodynamics is based on the study of the behavior of real bodies, in terms of characteristics which can be seen or felt—such as pressure, volume, temperature, and velocity. From the observed relations of these characteristics are established by definition new quantities, such as heat, work, energy, and others that are to follow, which are not as obvious to the senses. Often a mental picture of just what happens during a thermodynamic transformation may be developed from accepted views of the constitution of matter, the action of molecules, etc., but it must be remembered that this is done only to assist the memory and to satisfy natural curiosity. In no way do the findings of thermodynamics depend on such speculations; its entire structure rests upon observed relations between measurable quantities that are directly determinable by experiments on actual bodies.

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[14] Barnard, *op. cit.*, p. 2

Brief Explanations

The subject matter of "brief explanations," which are used so frequently in professional journals, concerns pieces of mechanism, processes of manufacture, theories of procedure. A brief explanation of a piece of mechanism or of a process may often be not much more than an expanded definition. It may include a definition proper. It usually stresses mainly some kind of analysis, either of structural or of functional details. The particular problems for the writer are selection of fundamentals, logical ordering of details, economy in phrasing. Such a piece of writing begins usually with a sentence of definition or information, proceeds at once with the detailed explanation, and closes with the last important detail of structure or use.

EXPLANATIONS

1

AN ANALYTICAL BALANCE

[A student theme]

An analytical balance is an extremely delicate instrument which is used to measure quantities of mass usually with an accuracy to one tenth of a milligram. However, the construction of the balance may be so varied that accuracy may be obtained to one milligram, or even a hundredth of a milligram.

The most common type of analytical balance consists of two balance pans which are supported from the ends of a horizontal cross beam by means of slender rods. The upper ends of these rods from each balance pan are attached to an agate prism, one edge of which rests in a grooved piece of agate fastened to the upper side of the horizontal cross beam. Agate is used for these contacts because of its hardness and its high resistance to wear. Also, such a contact allows the balance to swing freely with a minimum of friction. The cross beam is supported at its center by a similar agate contact. The degree of deflection of the cross beam is indicated on a scale by means of a long vertical pointer that is fastened to the cross beam. The cross beam itself is graduated into milligrams and tenths of milligrams and carries a platinum rider which may be moved to any point that is desired in order to balance the beam. The weight of the rider varies according to the length of the beam. The balance pans are supported from below in such a manner that they can be released

instantly without disturbing the equilibrium of the balance. The entire apparatus is enclosed in a glass case to prevent air currents and sudden temperature changes from affecting the readings.

In the actual weighing operation the object to be weighed is placed on the left hand balance pan and weights composed of either platinum or brass are placed on the right-hand pan until the addition of the smallest weight to the pan causes the pointer to be deflected from the right toward the left along the scale. These weights generally vary from 50 grams to 10 milligrams. The rider is then moved in either direction until no deflection of the cross beam from the horizontal position is indicated by the pointer. The apparatus is now "balanced."

[A. M.]

2

BLISS HYDRO-DYNAMIC HEADING PRESS[15]

Approved for Publication by the War Department

Cartridge cases can be headed at the rate of 250 to 300 an hour, with two pressings per case, on a 1500-ton hydraulic heading press brought out by the E. W. Bliss Co., 53d St. and Second Ave., Brooklyn, N. Y. The press shown in the illustration is used for heading 105-millimeter howitzer cases. It is equipped with a two-station pneumatically operated dial feed; a two-station punch-holder, operated pneumatically; a hydraulic ejector, driven by a 7½-H.P. motor; and a hand-operated air hoist. The main pumping unit is of 75-H.P. capacity.

The press is arranged to operate on a fully automatic cycle. When a case is placed in the forward station, pressing the start button will cause the dial to rotate, bringing out the previously pressed case and placing the new case under the press ram. When the dial is in its new position, the press will close rapidly, change speed before contact is made with the work, exert a given predetermined pressure, automatically reverse, and return to its starting position.

The reciprocating punch-holder then operates to bring a second punch into position automatically, and a second pressing cycle with another independent pressure is accomplished. Meanwhile, the ejector rises and ejects the finished case in the forward station during the first pressing, allowing the operator to pick the case off with the air hoist. During the second pressing, the ejector returns to its starting position, permitting the operator to put in a new case.

[15] *Machinery*, Vol. 48, No. 10 (June, 1942), p. 169

The entire cycle is fully protected against misoperation. The press ram cannot descend unless the dial and the punch-holder are in the proper pressing position. The dial and the punch-holder cannot operate unless the ram is in the upward position. Another safeguard is a device that automatically prevents the slide from descending if no work is in the press.

The several functions of the press cycle are separated by means of a selector switch, so that the press ram movement, dial movement, and punch-holder movement can be independently operated by the proper push-buttons when the die is being set up. The same safeguards against misoperation and the same interlocks for safety are provided when using hand control.

This press is one of several sizes available for heading different sizes of cartridge cases. Hydraulic presses are available for this work in capacities of from 600 to 3300 tons.

3

MAGNESIUM FROM SEA WATER[16]

In principle, the recovery of metallic magnesium from raw sea water is comparatively simple. Yet the development of a commercially successful process to utilize such a dilute source of raw material (1 part of Mg in 770 parts of raw ocean water) calls for unusual chemical engineering equipment, methods, and control. As developed by The Dow Chemical Co. for use in its new plant at Freeport, Texas, the process consists of the following steps: (1) Precipitation of magnesium hydrate from sea water using milk of lime made from oyster shells. (2) After filtration, the hydrate is converted into magnesium chloride using 10 per cent solution of hydrochloric acid. (3) The magnesium chloride solution is concentrated, first in direct-fired evaporators, then on shelf dryers, and finally, in a rotary dryer. (4) Flaked magnesium chloride, in practically anhydrous condition, is fed into the cells where it is electrolyzed to produce metallic magnesium of average purity between 99.9 and 99.95 per cent, along with byproduct chlorine (which is used to make HCl).

The molten magnesium is dipped from the cells and cast into 18-lb pigs for ease in handling. In this form it is an exceedingly light (Sp. Gr. 1.74) silver-white metal widely used in the magnesium alloys known as Dowmetal and for imparting hardness, strength, and fatigue resistance to various aluminum alloys.

Additional chlorine for make-up in the hydrochloric acid process

[16] *Chemical and Metallurgical Engineering*, Vol. 48, No. 11 (November, 1941), p. 130. A lengthy article on the same subject appears in the same issue of this periodical. Similar brief explanations, for example, "Smokeless Powder," April, 1942, appear in other issues of this journal.

is supplied at Freeport from Dow electrolytic chlorine cells. The dilute caustic soda effluent from these cells is concentrated to salable grades of liquid, solid, and flaked caustic. Natural gas is used throughout the plant for power generation, process heating, and as raw material for hydrochloric acid and chlorinated hydrocarbons.

Book Reviews

The reader of a book review generally wishes to know first what the author of the book has said, and second, what a competent critic thinks of it. The simplest kind of technical review is a bare statement of the contents of a book. The more elaborate review presents, in addition to this, the critic's estimate, favorable or unfavorable, of the book, and often the critic's own views about the theory or method advanced in it.

Most reviews, especially if they are brief, begin at once with some general statement about the purpose, or scope, or method of composition of the book. Following this, the writer may treat each section by itself, and at the end give his estimate of the book. Or the reviewer may treat the book as a whole, and summarize with brief comment what seem to him to be the most significant parts, thus doing away with a formal outline of the successive sections, important or unimportant, of the work reviewed. A longer review may introduce the matter by a discussion of the present state of the problem and then show by a clear analysis in what way the book in hand contributes to our knowledge of the subject. In every review, condensation, completeness of information, and simple language are essential.

The two one-paragraph reviews in Example 1 illustrate the simplest kind of technical review. They are limited to brief statements of contents and give, if at all, the slightest evaluation. The second and third examples are more elaborate.

BOOK REVIEWS

1

Power Plant Engineering and Design, 2 ed. By F. T. Morse. D. Van Nostrand Co., New York, 1942. 703 pp., illus., diagrs., charts, tables, 9½ x 6 in., cloth, $6.50.[17]

The aim of this book is to present in one volume a study of electric generating stations, including public service, industrial, and

[17] *Civil Engineering*, Vol. 12, No. 5 (May, 1942), p. 22

institutional plants. Steam plants are given most attention, but hydro-electric and Diesel-engine plants are also considered. The text assumes a basic knowledge of thermodynamics and mechanics and omits minor details of plant equipment and layout.

Hydraulics, 5 ed. By G. E. Russell. Henry Holt & Co., New York, 1942. 468 pp., illus., diagrs., charts, tables, 9½ x 6 in., cloth, $4.25.[18]

The fundamental principles of hydraulics are presented in a clear, logical manner for students and for use as a reference book by engineers. Although the text is devoted mainly to hydraulics, the flow of other liquids and of compressible fluids is briefly discussed. The basic text material has been completely revised for the first time since 1925, and the chapters on hydraulic turbines and centrifugal pumps, added in the previous edition, have been brought up to date.

2

Chemical Engineering Plant Design. Second edition. By F. C. Vilbrandt. Published by McGraw-Hill Book Co., New York, N. Y. 452 pages. Price $5.

Reviewed by R. H. McCormack.[19]

The second edition of *Chemical Engineering Plant Design* brings up to date one of the most helpful single books available for the teaching of this subject. The present increased production demand coupled with a great increase in relatively complicated synthetic processes makes the design course more important than ever before in the Chemical Engineering curriculum. The revision of this standard text will, therefore, be welcomed both by teachers and by the future employers of their students. Dr. Vilbrandt pioneered in the establishment of a workable technique in the organization of such courses and the additions in the new edition round out his former satisfactory treatment of the subject.

The principal changes have been made in the chapters on Development and Plant Location. New tables, illustrations, and nomographs appear throughout the book. Enlarged lists of collateral readings have been added to each chapter. Considerably more emphasis has been placed on safety engineering, in line with modern engineering practice. There has been some rearrangement of the chapters to provide a somewhat more logical and unified treatment of the course.

Dr. Vilbrandt succeeds in the second edition, as in the first, in

[18] *Ibid*

[19] *Chemical and Metallurgical Engineering*, Vol. 49, No. 5 (May, 1942), p. 209

including sufficient material to make his presentation clear and avoids with admirable restraint the temptation to enlarge on the subject. The assumption is implicit that students will have sufficient preparation in drawing to handle the mechanical aspects of their design work, but enough material on drawing is included to review this subject and act as a reference guide in the preparation of such drawings as the course may require. The same type of treatment is given to structures, engineering materials, fluid flow, and economics. These topics, and in fact, all but the material in the chapter "Development of the Design Project" are often covered in other courses in the chemical engineering curriculum. In this case, *Chemical Engineering Plant Design* becomes an extremely valuable summary of many courses integrated for the purpose of carrying out a design project. The various stages in the development of the design of a chemical plant are well illustrated and the role of the chemical engineer in such work is clearly defined.

To be complete, a text should include suitable student problems. These are grouped together in Appendices A, B, and C. The book is well furnished with illustrative problems indicating precisely the steps involved in the solution of design problems and projects.

3

Sales Engineering. Bernard Lester. John Wiley and Sons, Inc., 1940.[20]

Sales Engineering succeeds admirably in reaching the primary objectives stated by the author, ". . . to place before the younger sales engineer in simple terms, without sales promotion adornment, the principles of sales engineering, to indicate to him the importance of his burden, and to suggest the opportunities for him in present-day society." The book describes the field of sales engineering, discusses the work of the sales engineer in selling, and gives many useful suggestions regarding the development of the sales engineer. The style is readable and numerous case examples lend vitality to the discussion.

The clear treatment of fundamentals to be stressed in a sales training program should be helpful to those responsible for sales training work and particularly to young sales engineers in process of training. The book is not designed, however, to serve as a text for a course in salesmanship, nor could it be used directly as the major part of a sales training program in an individual company. To an experienced sales engineer the book would be interesting

[20] *The Journal of Engineering Education*, New Series, Vol. 32, No. 9 (May, 1942), pp. 789, 790

because of its well-organized description of selling practices and review of fundamentals.

Another and extremely valuable use is in portraying the field of sales engineering to young engineers during their college training. Altogether too many engineers consider that selling, even of technical products, is something akin to selling brushes door-to-door and will have none of it. As a result, many technical schools and colleges under normal conditions are not able to supply requests for potential sales engineers despite the fact that many of their graduates have the necessary personal aptitudes for success in selling. It is hoped that as many engineering students as possible have an opportunity to read Mr. Lester's book.

Technical Articles

The largest section in most technical journals is devoted to what may be called "technical articles." They are writings of greater length, of greater scope of subject matter, of greater complexity, than the pieces so far considered in this chapter.

The specimens which follow are fairly illustrative of this body of material.[21] Two general groups may be recognized: (1) pure exposition and (2) narrative exposition. A plain, unvarnished, informative, setting forth of facts or discussion of ideas or principles may be called pure exposition. Illustrative are "Belt Elevators," p. 366, and "What Would Compulsory Patent Licensing Mean to You?," p. 390. If we are telling how something has been done, how a piece of apparatus works, how an experiment is conducted, we are dealing with actions in a sequence, and the chronological order of arrangement is generally suitable. Such pieces as "Asphalt Cutoff Wall at Claytor Dam," page 363, and "The Baird Creek Bridge," p. 370, fall in this category of narrative exposition. A third kind of technical article, not illustrated here, may be designated as descriptive exposition. In such articles, the writers make use of whatever devices may contribute to the formation of a definite picture in the mind—comparison with familiar objects, reference to

[21] In the selection of these specimens, as of those in the earlier parts of this chapter, the authors have examined with some care recent issues of the following technical journals: *Aviation, Chemical and Metallurgical Engineering, Civil Engineering, Electrical World, Electronics, Engineering News-Record, Factory Management and Maintenance, Gas-Age, Industrial and Engineering Chemistry, Iron Age, Machinery, Marine Engineering, Mechanical Engineering, Mining and Metallurgy, Modern Plastics, Petroleum Engineer, Power,* and *Product Engineering.*

Students are referred to a greatly extended list of periodicals pertaining or closely related to engineering which appears in Gaum, Graves, and Hoffman, *Report Writing*, New York, 1942, pp. 288-301.

other and better-known types of the same thing, narration of the parts in operation.

All such writings may likewise be considered under three general headings as to style: (1) technical, (2) semitechnical, and (3) popular. If the purpose of the writer is purely explanatory, if he is dealing with the abstruse, the complicated, the scientific, if he is directing his articles to his professional colleagues, he is free to employ language which is highly technical and he need use no specific devices to make his meaning clear or his exposition interesting. His readers will be interested in the discussion purely for its own sake. The style of such a piece of writing may be called "technical." Approaching nearest to this kind of writing is "Drawing Dies for Airframe Stampings," p. 359.

Most of the specimens which follow are "semitechnical" in style. These articles are directed to the general professional reader. They must not be so technical in content or style, therefore, that the engineer with a general understanding only of the subject matter will be unable to understand what the writers are trying to present. The writers of such articles must pay special attention to their introductions, to the "telling of the story" in such terms as will engage the reader's interest, to the use of such illustrations as will help to present the picture more vividly. "Plastics," p. 382, may perhaps be chosen as a good illustration of this style of writing.

The third group of technical articles may be thought of as "popular" in style. The appeal is often to the unprofessional reader, that is, let us say, to the man who has a general acquaintance only with the particular matter under consideration. He does, however, have a sympathetic and emotional as well as intellectual interest. He approaches the reading of an article from somewhat the same point of view as that of the reader of a biography or a novel. To the writer, therefore, the challenge comes to surround the technical or scientific nucleus of his subject matter with elements of material and style which will interest as well as inform. "Engineering and Art," p. 394, as the title implies, makes an appeal to the "human" interests of the engineer and may therefore be thought of as "popular" in the best sense of the word.

Many suggestions for the writing of technical expository articles have already been presented in this book: in Chapter 1,

General Problems; in the chapters on Correspondence and on Report Writing; in the foregoing sections of the present chapter. Supplementing these suggestions and applying specifically to articles in technical journals is the following summarizing discussion.[22]

1 State in your title as specifically as possible the phase of the subject which is to be treated in your article. For greater clearness, a subtitle is often desirable.

2 Have in mind the reader. Try to look at the subject from his point of view. Adjust your language and your methods to his comprehension. Don't overestimate or underestimate either his knowledge or his intelligence.

3 Regard your subject as a whole and plan your presentation as a whole. Treat your subject as a unit of logical discourse, no matter whether it demands a short editorial or a long historical, narrative, technical article. Select the essentials of the specific aspect of the subject that you are treating. Don't feel that in a single article you must say all that you know on the subject.

Decide clearly what you are going to write. Test your thinking by summarizing the article in a paragraph. If you cannot state the heart of your message in two or three simple sentences, you haven't it clearly in mind.

4 Make an outline, stating in order the subject for the lead, the main points of the body, and the end. Do not make this working outline too detailed. Jot down the subordinate material under each of the main points. Be sure your outline satisfies you before proceeding to the next step.

5 Write your rough draft, putting in as subheads the words: Lead, Nature of the Problem, How Solution was Reached, The Solution and Benefits, Ending, or other suitable definitive leads, in appropriate places. These words, for which less obvious subheads should be substituted in the final draft, will help you keep the major parts of your paper in mind and get the details in their proper place.

6 When you have finished the first draft, put it aside for

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[22] For many of the admirable suggestions or directions of this discussion, the authors are indebted, directly or indirectly, to (1) *Writing the Technical Paper*, by F. H. McEnanem of The Westinghouse Electric and Manufacturing Co. and (2) *Information to Authors*, American Institute of Electrical Engineers (1940), pp. 15, 16. See also George A. Stetson, "The Art of Technical Writing," in *The Journal of Engineering Education*, Vol. 23, No. 6 (February, 1933), pp. 491-498.

a day or two and forget about it. Then take it out, and go over it critically. Cut out every needless word. Substitute a little word for every unnecessarily big one. Suspect the value of every word over three syllables.

7 The beginning of the paper is your bait to the reader. If you lose him there, you will never get him back. In technical articles the reader usually wants to know at once what your piece is about. If you have something new to announce, say so. If your article discusses nothing new, catch the reader with a beginning he can't help but read. (See the diagram on page 348.) Axioms of the writing craft insist on this idea: "Something human in the first 20 words." "People are interested first of all in human beings, second in things, least in abstract ideas." "Proceed from the concrete to the abstract; from the known to the unknown."

Specifically—you may begin with a definite statement of the subject to be covered, an enumeration of points to be treated, a definition of terms, a background for the particular discussion. The reader wishes this information in the quickest and easiest way possible. A long formal discussion may require a separate formalized opening, such as the following:

> 1 Purpose. The purpose of the present discussion is to examine recent developments in bridge-building techniques, and to give examples from specific bridges.
> 2 Scope. The discussion here is limited to reinforced concrete highway bridges built in the last five years.
> 3 Method. Materials here used are gathered from an examination of reinforced concrete bridges built since 1939 by the Tennessee Highway Commission. The material is supplemented by a study of periodical literature about similar bridges built in other sections of the country in the same period.

8 The body of your article consists of what you want the reader to know. It should be contrived to make certain definite points, and *these points should be few in number—if possible not more than three.* Each main point may be supported by innumerable lesser points, selected and presented in such a manner as to build up the main point. In the typical engineering article, the main points should tell (1) what the problem

was, (2) how the author or his colleagues undertook to solve it, and (3) what the solution and the benefits are. (See the diagram on page 348.) Virtually all engineering articles can be fitted into this simple structure.

In writing, move along smoothly, letting the ideas flow onto the paper. Develop each point fully; then move on to the next. Do not repeat. Do not mix your ideas. Do not use flowery language, or words that do not mean precisely what you want to say. Keep the story moving. Avoid wordiness. Remember the writer's rule: "Think twice before using an adjective." Do not try to *impress* your reader; tell him simply what you have in mind. Keep your paper short: "No souls are saved after the first twenty minutes."

9 Use concrete instances or examples. Concrete instances will often do more toward a clear explanation than pages of abstract discussion. Examples must, naturally, be familiar to the reader; otherwise they will involve or obscure the subject instead of clarifying it.

10 Compare the new with the old and thus bring out forcibly the relative advantages of the new. In an attempt to explain a new invention, a comparison of its main points with those of some well-known machine will help the reader toward a clear understanding of the new machine.

11 Use in the course of your discussion summarizing sentences or paragraphs looking back on the ground covered and looking forward to what is to follow. Don't at any time keep your reader in the dark about the main idea of your article. Stages in the progress of your exposition should be clearly indicated. Indicate by mechanical devices such as headings or numbers, or by phrases of connection, or by other methods of articulation, the logical progression of your thought.

12 Be sure that your paragraphs, whether long or short, are justified as units of thought.

13 Avoid long and involved sentences.

14 Avoid the excessive (and often incorrect) use of such loose expressions as "in such case," "a number of," "in connection with," "etc.," "and/or," and the careless use of such words as "occur," "considerable," "very," and "locate." See the discussion of jargon in Chapter 2.

15 Do not split infinitives. This rule, like most good rules, admits of exceptions. If you think that the split infinitive makes

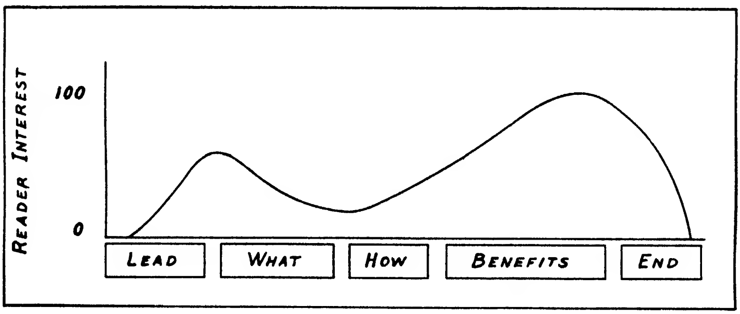
for greater strength or clearness, use it; if not, don't. Also, in more formal writing, try to avoid separating auxiliary verbs from their main verbs. Example: "The process *can be controlled* accurately and effectively . . . ," rather than "the process *can be* accurately and effectively *controlled*."

16 Give definite dates and values wherever possible. For example: "in July, 1935," not "a few years ago"; "a resistance of five ohms," not "a resistance of a few ohms."

17 Make your references, whether in the form of footnotes or of bibliographical summary at the close, clear, accurate, and complete.

18 **The end** of your article is your last chance with the reader; it must leave him with the information or the emotional reaction which you wish to convey. In technical papers it often takes the form of a summary, or conclusions drawn from data. It may be only a sentence or two, but it should, like coffee after a good dinner, fix in the reader's mind the essential flavor of your message, give him complete satisfaction, and round out the performance.

19 Use illustrations, graphs, charts, etc., wherever they will help your meaning or improve the effectiveness of the paper. But do not use any more than are necessary. Consider your graphs, charts, and tables critically. Do they really clarify matters? Are they presented in the simplest, most graspable form? Let each illustration, whether chart, graph, or table, stand on its own feet as a unit. The reader should be able to understand it without reference to the text.



Theoretical "U-shaped" curve of interest created by a properly constructed technical article.

TECHNICAL ARTICLES

1

MANUFACTURE AND PROCESSING OF ALUMINUM AND ITS ALLOYS[23]

by Paul P. Zeigler
Chief Metallurgist, Reynolds Metals Company, Louisville, Ky.

OUTLINE[24]

I *Introduction*
¶1 A Outstanding quality of aluminum alloys—low specific gravities
B Suitability for application—where conservation of weight is an important factor
Ex. aircraft industry
C Purpose of paper—to familiarize engineers with aluminum, its preparation, and fabrication of alloys into wrought products

II *History*
¶2 A Abundance of aluminum in oxidized compounds
¶3 B Isolation of pure metal

III *Reduction of Aluminum*
¶4 A Use of oxide of high purity
B Two stages of manufacture of metallic aluminum
¶5 C Steps in the Bayer process for the extraction of pure alumina
D Electrolytic reduction of pure alumina to metallic form
¶6 1 Use of large cells filled with molten cryolite
¶7 2 Operation of cells at temperatures of about 1000 C
¶8 3 Requirement of electrical energy for each pound of metal—from 10 to 11 kwhr
¶9 4 Addition of pure alumina, deposition of metallic aluminum, drawing off of the metal

IV *Strengthening of Aluminum*
¶10 A Plasticity of aluminum of high purity
B Possibility of increasing its strength and hardness
C Three general methods
¶11 [Transition paragraph]

V *Common Alloys*
¶12 A Increased strength in annealed condition from alloying elements

[23] *Mechanical Engineering*, Vol. 64, No. 2 (February, 1942), pp 106-108, 131
[24] This outline was prepared by the authors of this book.

B Further increased strength from introduction of cold work
C Examples of alloys in general use

VI *Strong Alloys*
¶13 A Development of heat-treatable alloys of aluminum
¶14 B Two types of age-hardened alloys
¶15 C Process of Age-Hardening
1 Heat-treatment operation—heating, soaking, quenching
2 Age-hardening at room temperature
3 Development of full hardness by reheating
4 Nature of the precipitation process
¶16 D Precipitation in spontaneous-aging type and in artificial-aging type

VII *Remelting*
A The purpose of aluminum remelting
¶17 1 First step in process of conversion of pig iron to wrought commodities of engineering value
¶18 2 Twofold purpose
¶19 B [Limitation of the discussion to wrought alloys]
¶20 C Use of the open-hearth type of furnace
D Process of conversion
¶21 1 Heating
¶22 2 Elements generally used
3 The making of the alloy

VIII *Forming Operations*
A Hot-forming
¶23 1 Forms of pure aluminum and wrought alloys
2 Elevated temperatures for first forming of the ingots
3 Nature of first hot-forming operation
(a) Thin, long, wide ingot for sheet and plate products
(b) Long ingot with a square cross section for the production of rod, bar, and certain structural shapes
(c) Cylindrically shaped ingots for extrusions
¶24 B Preheating operation prior to first steps in hot-forming
1 Necessity in all but the simpler common alloys and high-purity aluminum compositions

2 Purpose
3 Temperatures
C Cold-forming processes following the hot-working
1 Necessity for such products as wire, cold-finished rod and bar, tubing, and sheet
2 Kinds of processes
(a) Wire-drawing
(b) Tube-drawing
(c) Cold-swaging
(d) Cold-rolling
3 Nature of processes
(a) Hardening
(b) Intermediate annealing operations
(c) Controlled temper for common alloys
¶25 4 Restricted application of processes

IX *Finishing*
¶26 A Necessity after fabrication of heat-treatment of alloys amenable to hardening
B Process
C Straightening and flattening operations
1 Roller leveling for sheet and some plate
2 Roll straighteners for round rod
3 Stretching for bars of noncircular cross sections and extruded shapes
4 Similar operations for common alloy products

X *Pureclad*
¶27 A Purpose
B Nature
C Gain from use of product
¶28 D Application
¶29 E Additional gain from prevention of attack on exposed sheared sections of base alloy

XI *Mechanical Properties* [Reference to tables]

TEXT

1 Most outstanding quality of the aluminum alloys is their low specific gravities as compared to other commonly used metals. Roughly, alloys of the aluminum family weigh only one third as much as equal volumes of steel, copper, brass, and bronze. In addition, their tensile strengths range from 13,000 psi in the soft, relatively pure aluminum to tensile strengths comparable to those of structural steel in the so-called strong alloys. As a consequence, aluminum alloys are pre-eminently suited for applications where

the conservation of weight is an important factor. Indeed, their application is so extensive in the aircraft industry that aluminum has come to be known as the airplane metal. The recently proved military value of the airplane, moreover, has created such a demand for aluminum alloys that the whole world has become aluminum-conscious. This paper, therefore, has been prepared for the benefit of those engineers who wish to become more familiar with aluminum, its preparation, and the fabrication of its alloys into wrought products.

History

2 Aluminum is the third most abundant element available. Clark estimates aluminum to constitute about 7.85 per cent of the earth's crust. Aluminum never occurs in the native form, and because of the element's great affinity for oxygen, aluminum, with the exception of its fluorides, invariably occurs as oxidized compounds.

3 Alum, from which the element takes its name, was known to the Greeks and Romans. As early as 1746 Pott showed that alum was derived from a peculiar earth which he called "alumina." Davey, who always regarded this earth as an oxide of a metal, eventually isolated the metal in an impure form in 1807 and called it "aluminum." The pure metal was first isolated in 1825 by Oersted, and two years later by Wöhler. In 1886 Hall, in the United States, and Héroult, in Europe, simultaneously began the production of aluminum by the electrolysis of aluminum oxide dissolved in a molten bath of cryolite. This process, which made commercial production of aluminum feasible, is now responsible for the entire world's production of the metal.

Reduction of Aluminum

4 Because in the electrolytic reduction of aluminum oxide any impurities such as the oxides of iron, silicon, and titanium are reduced along with the alumina, an oxide of high purity must be used. As a consequence, the manufacture of metallic aluminum comprises two main stages: The first stage embraces the production of pure alumina, Al_2O_3, from the ore, and the second comprises the electrolytic reduction of the pure Al_2O_3 to metallic form in a bath of molten cryolite.

5 Although a number of commercial methods have been developed for the production of high-purity Al_2O_3 from aluminous materials, the Bayer process is almost universally used for the purification of bauxite. Inasmuch as an overwhelming preponderance of metallic aluminum is manufactured from bauxite,

the Bayer process is by far the most extensively used method for the extraction of pure alumina. In outline form the Bayer process is as follows:

1 Bauxite is dried in rotary kilns.

2 The dry bauxite is ground very fine, usually in ball mills.

3 The pulverized material is dissolved with strong sodium-hydroxide solutions in autoclaves at a temperature of 150 C under pressures of four to five atmospheres.

(a) Al_2O_3 is dissolved as sodium aluminate.

(b) Iron, silicon, and titanium remain insoluble.

4 Solutions are diluted and allowed to settle four or five hours.

5 Settled solutions are filtered.

6 The aluminum is precipitated as $Al(OH)_3$ by adding freshly precipitated crystals of $Al(OH)_3$.

Precipitation usually requires sixty hours.

7 $Al(OH)_3$ is filtered out of the solution and washed.

8 The pure $Al(OH)_3$ is roasted in rotary kilns to yield Al_2O_3.

6 The electrolytic reduction is carried out in large cells which are essentially steel boxes lined with carbon and filled with molten cryolite. Carbon annodes are suspended in the tops of the cells while the carbon linings function as the cathodes. Numerous types of cells are in use. As many as twelve separate anodes may be used in one cell, or only one huge anode may be employed.

7 The cells, or pots, as they are called within the industry, are operated at temperatures of about 1000 C. At this temperature the cryolite is able to dissolve approximately 10 per cent of its weight of alumina. Current densities of 4 to 8 amp per sq in. are used. The passage of such large current densities generates sufficient heat to maintain the bath temperature so that external heating is not necessary.

8 The theoretical decomposition electromotive force is considered to be 2.8 volts with a theoretical current consumption of 1337.5 amp-hr per pound of metal. Consequently, the theoretical energy requirement amounts to 3.75 kwhr for every pound of aluminum reduced. In practice, cell voltages of 4 to 6 volts are common, while current efficiencies of 70 to 90 per cent are usually reported. For the commercial reduction of metallic aluminum, therefore, each pound of metal requires from 10 to 11 kwhr of electrical energy.

9 As electrolysis progresses, alumina is consumed in direct proportion to the amount of metal reduced. Additional alumina is supplied to the impoverished bath by stirring it into the surface. The metallic aluminum, having a greater specific gravity than the

molten cryolite bath, collects in the bottom of the cell. When a sufficient amount of metal accumulates, it is drawn off and cast into pig ingots. Metal may be drawn from a cell every few minutes, every day, or every third day, depending upon the design of the cell and local operating conditions. Every attempt is made to keep the purity of the virgin pig as high as possible.

Strengthening of Aluminum

10 Aluminum of high purity is relatively weak, but it possesses excellent plasticity. Approximately, its tensile strength is only one fourth to one fifth that of structural steel. Obviously, the utility of aluminum would be greatly limited were it not possible to increase its strength and hardness. The art of metal-working and the science of metallurgy, fortunately, have developed three general methods of strengthening and hardening metals, as follows:

1 Strain hardening by cold work.
2 The addition of other metals and metalloids to form alloys.
3 Thermal treatment of certain types of alloys.

11 These three methods of metal hardening have been applied to aluminum, giving rise to two commercial classes of alloys which are generally known as common and strong alloys.

Common Alloys

12 The common alloys derive their increased strength in the annealed condition by virtue of the alloying elements employed. Further increases in the strength of the common alloys can be obtained only through the introduction of cold work, as by cold-rolling, wire- or tube-drawing, cold-swaging, and the like. They are not amenable to hardening by thermal treatment. Examples of the common alloys in most general use are 2S, 3S, and 52S. The alloy 2S is aluminum of commercial purity containing a minimum of 99 per cent aluminum with controlled amounts of silicon, iron, and copper as impurities.

Strong Alloys

13 In 1911, Wilm in Germany discovered that certain aluminum alloys when water-quenched from high temperatures exhibit remarkable increases in strength and hardness after several days' aging at room temperature. His discovery led directly to the development of Duralumin and pointed the way to the development of the numerous heat-treatable alloys of aluminum in existence today. Because of the greater strength of these latter alloys, as compared to the older alloys of aluminum, they were called strong alloys.

14 As we have seen, strong alloys owe their greater strength principally to the state of their physical structures as induced by thermal treatments. These alloys have a remarkable ability to age-harden. In general, two types of strong alloys exist: those which completely age-harden spontaneously at room temperatures, and those which require slightly elevated temperatures to develop complete age-hardening. Alloys 17S and 24S are examples of the former class, while 25S and 51S are examples of the latter class.

15 In order to develop age-hardening in strong alloys, it is first necessary to subject them to a solution heat-treatment. This consists of heating the alloys to the highest temperatures used in the thermal treatment of aluminum alloys. These high temperatures are maintained long enough to obtain saturated solid solutions of the particular alloying constituents in the aluminum space lattice; and at the end of the so-called soaking period the metal is drastically cooled by a sudden quench in cold water. The cooling is so sudden that the solid solutions are temporarily retained at the lower temperature in a state of unstable thermodynamic equilibrium. In the aluminum industry the whole cycle of heating, soaking, and quenching is called the heat-treatment or heat-treating operation. Immediately after the quenching the alloys possess characteristics typical of solid solutions. In this condition they are relatively soft and plastic. Age-hardening develops rapidly, however, in those alloys which age-harden spontaneously at room temperatures, so that very appreciable increases in tensile strengths occur within one hour after the quenching operation. By the end of three or four days the aging process is practically complete, and the alloys are in their fully age-hardened condition. In those alloys requiring elevated temperatures to develop age-hardening after the quench very little hardening occurs at room temperatures. These alloys remain relatively soft and plastic and, consequently, are readily formed in the as-quenched condition. Full hardness is developed by reheating to moderate temperatures at any convenient time after the quench. The hardening which develops by aging at room temperature or at slightly elevated temperatures results from the slow precipitation of the solute constituents from the unstable solid solutions. The exact mechanism of the precipitation process is not completely understood at this time, and the whole subject is under intensive investigation. It is believed that the finely dispersed particles of the precipitate orient themselves within the solid-solution matrix in such a manner as to increase resistance to slippage along the crystallographic slip planes of the parent lattice.

16 Apparently, there is sufficient atomic mobility at room temperature to allow the precipitation to proceed sufficiently to

develop hardness in the spontaneous-aging type of alloys. In the alloys which do not completely harden spontaneously at room temperature, sufficient atomic mobility is obtained for precipitation of solute constituents by holding the alloys at temperatures of 300 to 350 F for periods of time ranging from eight to twenty-four hours. The reheating after quenching is frequently referred to as precipitation heat-treatment or artificial aging.

Remelting

17 The first step in the conversion of pig aluminum to wrought commodities of engineering value comprises remelting and casting operations.

18 Except for very specialized cases of certain types of aluminum-alloy scrap, which is always fed into the remelting furnaces along with the virgin pig, little or no refining can be accomplished by the remelting operation. Consequently, we may say the purpose of aluminum remelting is twofold:

1 To add the required alloying elements.

2 To cast the metal into finished or semifinished products, or into convenient shapes for subsequent fabrication into wrought commodities.

19 Because the scope of this paper is limited to the production and processing of wrought products, only wrought alloys will be discussed.

20 The open-hearth type of furnace is used almost exclusively for remelting wrought aluminum alloys. Essentially, these furnaces consist of a shallow hearth and suitable heating arrangements. In this country the hearths are generally lined with firebrick, but in Europe the tendency seems to be toward the use of the more expensive magnesite-brick linings.

21 Heating is accomplished by the conversion of electrical energy to thermal energy, or by the combustion of fuels such as coal, gas, oil, and coke. Coke-fired furnaces are by far the most prevalent in the United States.

22 The elements most commonly used in the production of commercial wrought aluminum alloys are copper, magnesium, silicon, manganese, iron, zinc, chromium, and nickel. They may be used singly or in combination, but the total content of alloying elements in a given alloy is seldom more than 6 or 7 per cent. Except for the magnesium and zinc, the alloying elements are generally added to a bath of molten pig and scrap in the form of auxiliary or so-called hardener alloys. Copper, for example, is added in the form of a 33 per cent copper alloy of aluminum corresponding to the eutectic composition for the copper-aluminum system, and manganese is added in the form of a 5 per cent man-

ganese auxiliary alloy of aluminum. The metals zinc and magnesium are generally added in commercially pure form by means of special tools, by which the metal is kept completely submerged under the surface of the bath so as to prevent excessive oxidation. Having obtained the desired molten alloy, the metal is cast into ingots of convenient size and form for the forming operations.

Forming Operations

23 Pure aluminum and the wrought alloys of aluminum are available in numerous forms, such as foil, sheet, plate, wire, rod, bar, tubing, rolled structural shapes, and a multitude of oddly shaped extrusions. Aluminum alloys, like most metals and alloys, are relatively brittle in the cast state, and, consequently, the first forming of the ingots must be conducted at elevated temperatures where the increased ductility and plasticity will prevent cracking and breaking under the pressures and forces applied. The first hot-forming operation employed depends on the final product desired. For sheet and plate products a relatively thin, long, wide ingot is rolled between cylindrically shaped rolls. A long ingot with a square cross section, on the other hand, is hot-rolled in a box-shaped pass as the first step in the production of rod, bar, and certain structural shapes. Cylindrically shaped ingots are usually employed for extrusions, including tubing, rod, and variously shaped cross sections.

24 In all but the simpler common alloys and high-purity aluminum compositions, a preheating operation is required prior to the first step in hot-forming. The preheating serves to homogenize and soften the cast structure, making it more amenable to forming without fracture. The preheating temperatures range from 850 to 900 F, depending on the alloy and type of ingot. The temperatures of the metal during hot-forming also vary from 500 to 900 F, depending on the type of alloy and the stage and type of hot-forming processes. Many products are hot-worked to finished form. Some examples are extruded shapes, certain types of rod and bar, rolled shapes, and heavy plate. In the fabrication of other products, such as wire, cold-finished rod and bar, tubing, and sheet, the hot-working is followed by cold-forming processes, such as wire-drawing, tube-drawing, cold-swaging, and cold-rolling. As cold-forming proceeds, the metal is hardened by virtue of the cold deformation, so that intermediate annealing operations are required from time to time in order to soften the metal sufficiently for reduction to final form. In the common alloys the tensile strength and degree of hardness, i.e., the temper, is governed by the amount of cold deformation introduced subsequent to the last annealing operation.

25 Many products, such as extruded shapes, cannot be cold-worked appreciably, and, consequently, such products when fabricated in the common alloys, cannot be produced with controlled tempers, except for the soft or annealed temper.

[Tables omitted]

Finishing

26 Alloys which are amenable to hardening by thermal treatments are heat-treated after the product has been fabricated to finished dimensions. As explained previously, the heat-treatment consists of drastically quenching the metal in water from high temperatures. The sudden cooling causes considerable twisting and warping of the fabricated forms, so that straightening or flattening operations, or both, are required. Sheet and certain thicknesses of plate are flattened by roller leveling and stretching. Round rod is generally straightened by roll straighteners, while bars of noncircular cross sections and extruded shapes are straightened by stretching only. Similar straightening and flattening operations are also conducted on common alloy products to improve the flatness or straightness, or both, of the material as produced by the various forming operations.

Pureclad

27 Although all aluminum alloys exhibit relatively good resistance to corrosion, some of the heat-treated and aged strong alloys are considerably less resistant to corrosion than aluminum of high purity. To combine the great strength of strong alloys with the excellent corrosion resistance of the pure metal, a product called "pureclad" has been developed. Pureclad consists of a strong-alloy core between two films of high-purity aluminum. The thickness of the high-purity surface films is so chosen as to retain the maximum physical properties consistent with adequate protection of the alloy core against corrosion. Standard pureclad sheet products are fabricated with each film thickness amounting to approximately 5 per cent of the total thickness of the sheet. As a result, the tensile and yield strengths are approximately 10 per cent lower than corresponding values for the uncoated alloys.

28 The high-purity films are applied during the hot-roll operations. A slab of core metal consisting of one of the strong alloys, for example, 24S, is encased between two plates of high-purity aluminum containing a minimum of 99.7 per cent aluminum. The assembled slabs are heated to hot-rolling temperatures of approximately 800 F, depending on the particular core alloy, for

the rolling operation. On the first pass through the roll the high-purity plates are welded onto the strong alloy core so as to make the coatings integral parts of the complete slab. From this point on, the material is finished by subsequent hot-rolling and cold-rolling, exactly the same as ordinary sheet or plate would be. After the plates are once welded securely to the core metal, the relative thicknesses of the high-purity plates remain substantially constant, regardless of the amount of reduction made on the material.

29 It is a fortunate coincidence that the coating not only protects the alloy which it covers, but also prevents attack on the sheared edges or the sections of the base alloy which may be exposed by scrapes and abrasions. Such electrolytic protection arises through the more anodic character of the film as compared to the core.

Mechanical Properties

30 In conclusion, nominal chemical compositions and typical mechanical properties of some of the more widely used common and strong alloys are given in Tables 1 and 2 to show the wide range of mechanical properties covered by aluminum alloys.

2

DRAWING DIES FOR AIRFRAME STAMPINGS[25]

By G. A. Brewer

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. . . Automotive stamping practices are being applied to the manufacture of airframe parts. Tool steel or cast iron dies are not necessary—Kirksite "A" die material performs efficiently on quite lengthy runs in the double acting press.

Increased recognition of the importance of aircraft in the past two years has placed demands upon the industry for airframes in unprecedented quantities. In an effort to meet this demand the attention of the aircraft industry was at once directed toward the possibility of applying automotive stamping practices to the manufacture of airframe parts. The general principles involved in such applications have been thoroughly discussed,[1] but here will be considered the specific and all-important subject of low cost tooling for aircraft stamping work.

In spite of early-day beliefs to the contrary, similarities in detail between airframes and automobile bodies do exist. Both are made

[25] *The Iron Age*, Vol. 149, No. 22 (May 28, 1942), pp. 37-41

principally of sheet metal formed to developable and non-developable surfaces. Both are joined by gas, electric, machine, and spot welding as well as by conventional fastening methods such as riveting and bolting. Except for size, the modern bomber fuselage is not unlike the modern automobile body. However, two factors must be considered before a ready adoption of automotive stamping practice to airframe components can be made. Aircraft, to be efficient, must be constructed of material that is light, strong, and stiff. For present day airplanes, the various aluminum alloys such as 24S, 61S, 53S, and 52S represent the most efficient structural material available. These aluminum alloys, in the harder tempers, have decidedly limited formability, and even in the soft tempers they are by no means so formable as the deep drawing steel used for automobile bodies.

The most serious consideration of all, however, is not the limited formability of the aluminum alloys, but the enormous cost of tooling that would exist if aircraft dies were to be made of tool steel or high strength cast iron, following automotive practices. Upwards of 10,000 parts are required to make the frame of a modern bomber whereas but 1600 parts are necessary for the modern sedan body. Furthermore, the cost of the dies for the sedan can be spread over several hundred thousand units, whereas in the case of the bomber five times as many dies must be amortized over 2000 or 3000 units at the most. Furthermore, tryout runs and reworking must be reduced to a minimum for airframe dies or the total cost rises tremendously.

This situation made it a traditional saying in the aircraft industry that: "We can't afford automotive-type tooling." However, such statements overlooked one major saving possibility. The very fact of relatively low production quantities in the aircraft industry permits the successful use of die materials of relatively limited life—materials that are easily cast, reclaimed, and machined. In this way the singularly effective *principles* of automotive tooling, such as drawing and stretching, can be utilized and the high cost avoided.

The economic and production advantages in using soft die materials for airframe stamping may be recognized in efforts both in this country[2] and abroad[3] to use wood, zinc, aluminum, magnesium and plastics as die materials. At the Lockheed and Vega aircraft plants, a system utilizing a photographic lofting technique in conjunction with plaster patterns and a proprietary zinc-aluminum die material known as Kirksite "A" has been found to be highly efficient.[4] This system produces satisfactory drawing and stretching dies with great savings in time and cost as compared to any system using cast iron or tool steel die mate-

rials, and has been found to involve time and cost advantages over the use of wood as a die material.

An outline of the photo loft-plaster pattern Kirksite die system is as follows: (1) The loft board is photographed on overlapping glass negatives; (2) the desired section is projected on the sensitized metal surface, enlarged sufficiently to allow for the Kirksite shrink scale; (3) the exposed metal blank is developed; (4) templates are cut out of the metal blank using the photographic lines; (5) templates are mounted on a board and supported by wire framework; (6) plaster is poured into the framework to within about ¼ in. of the top of the templates and allowed to dry; (7) the finish coat of plaster is applied, and the shrink-mockup of the portion of the ship is complete; (8) plaster "splashes" are then taken from any portion of the mockup to be used for making sand molds for cast dies; (9) sand molds are made from plaster "splashes"; (10) Kirksite "A" is poured into the sand molds and allowed to solidify; (11) the finished die then is ground to size. The inherent speed in the process is due entirely to the fact that no laborious calculations or drafting are necessary once the original lofting work has been completed.

Kirksite is easily machined and, by casting the die almost to size, little machining other than finish grinding is required. Because of its low melting temperature, shown in Table I,[26] Kirksite is readily reclaimed and foundry technique is simplified. The larger aircraft concerns already are equipped with Kirksite foundries, as it is regularly used as a drop hammer die material.

One of the most cogent arguments advanced against the replacement of the drop hammer by the double-acting press for forming aircraft parts has been that the economies of using Kirksite as a die material must necessarily be lost in any conversion to the double-acting press, since the use of the latter was commonly supposed to involve a die material of tool steel or high strength cast iron.

It seemed logical to assume, however, that since Kirksite successfully withstood countless impacts on the drop hammer, it could hardly be ignored as a possible die material for use in the relatively shockless double acting press. Accordingly, the research department at Lockheed Aircraft Corp. made a 12-in. cupping die and drew a number of parts on it, making frequent examinations of the surfaces of both the parts and the die. After some 77 parts had been drawn, the surface of the die showed no evidences of deleterious wear, and the drawing radius appeared to be more highly polished than in the beginning, as illustrated in Figs. 1

[26] Table and all Figures omitted

and 2. The conclusion was reached that the die would last for several hundred more parts and recommendations were made to try Kirksite as a drawing die material on a small scale in actual production.

In the six months following this recommendation, over 150 Kirksite double-acting dies, exclusive of a large number of double-acting dies converted directly from drop hammer dies, have been constructed and have passed tryout tests. The largest run to date has been that of 3685 boxes, drawn on the die shown in Fig. 3. To date only a few hundred parts have been drawn on other dies, shown in Figs. 4 and 5, but no signs of deleterious wear are yet visible. It is of interest to note the successful use of this material on drawing dies of the comparatively large size, as illustrated in Fig. 6.

Although the harder tempers of the aircraft aluminum alloys, such as 24ST, heat treated Alclad, cannot be readily drawn, they can be stretched to a useful degree. Fig. 7 illustrates the use of Kirksite as a stretching punch on a large double-acting press. No bottoming die is used, the sheet being clamped to supporting rails by the hold-down ram. The contoured nacelle skins stretched from 24ST material on a typical run are shown in Fig. 8. These were made at the rate of 90 per hr, and the time saving as compared to laborious drop-hammer formation is obvious.

The successful use of Kirksite as a draw die material at Lockheed and Vega plants has virtually eliminated the use of high strength cast iron or tool steel except in cases involving unusually severe conditions or extremely long runs. In such cases where it is planned to use a harder material for the final die, it is often found advisable first to make the die in Kirksite since any modifications necessary for successful operation can hardly be made in the hard material. Then after the successful tryout with the Kirksite the die may finally be made of the harder material with little risk of failure.

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3

ASPHALT CUTOFF WALL AT CLAYTOR DAM[27]

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Contents in Brief—A cutoff wall of a sand-asphalt mix was used at the Claytor hydroelectric project near Radford, Va., to stop underflow through the north abutment of the dam. A sheeted trench was sunk through the overburden to rock, and, after all solution channels had been cleaned out, the trench and all rock channels were filled with the hot sand-asphalt mix to above reservoir level.

One of the chief problems faced in construction of the Claytor hydro-electric project on the New River near Radford, Va., was development of a method for checking underflow through the north abutment. which consists of a dolomite rock, badly cut by solution channels and overlain with rock fragments and clay. The problem was met by the novel expedient of filling a cutoff trench with a hot sand-asphalt mix, as described briefly in the general article relating to the Claytor project in ENR, March 13, 1941, p. 392. Because this is the first major application of asphalt to cutoff wall construction, the following details of the work are given.

Before starting construction, intensive drilling operations were carried out across the north abutment to locate the existing water-table contour at a point 4 ft above the projected pond level of El. 1846. A consistent water table at that level was not found until about 600 ft back from the dam, making it evident that the rock grouting for the dam foundation would have to be extended to that point if a tight seal was to be obtained.

Locating the Ceiling Line

As the rock cliff, into which the north end of the dam is keyed, disappears underground a short distance beyond the crest of the slope, a large amount of exploration was necessary before sufficient information could be obtained for locating the sealing line in the most satisfactory position. The abutment first was spudded in an effort to obtain the depth of the overburden, but as the results were inconclusive, it was decided to uncover the rock on a line which the spudding operation showed to be the most favorable.

[27] *Engineering News Record*, Vol. 128, No. 13 (March 26, 1942), pp. 66-68. See an editorial on this subject in the same issue of this journal, reprinted on page 327.

This work resulted in a sheeted trench 340 ft long, averaging less than 4 ft wide and ranging from a few feet to 150 ft deep.

The overburden was found to be residual clay containing some beds of water-borne gravel and a few boulders. Below the clay the rock was a yellowish gray dolomite stratified with shale containing bedded chert.

The cause of the seemingly inconsistent results obtained by spudding was revealed when the rock was uncovered. Due to solution, the elevation of the rock surface was extremely variable and the formation contained many water passages and deep pockets filled with clay which had to be excavated.

The surface of the rock was below El. 1850 (4 ft above pond level) for a distance of about 255 ft, and, as there was some doubt as to the ability of the overburden to resist excessive seepage, it was decided to backfill the trench below El. 1850 with some impervious material. Reinforced concrete was at first proposed but was rejected for the following reasons: Reinforced concrete lacks flexibility and would have been very expensive and difficult to place because of the narrow width and great depth of the trench. The use of reinforced concrete would have required the removal of the trench timbering, which had been in place for many months. Although the timbering was strongly braced, there was sufficient "working" of the members to indicate that it was sustaining heavy pressures; hence its removal would have been an extremely hazardous undertaking. Puddled clay was also considered, but its placing had some of the objectionable features of reinforced concrete, particularly as it too would require the removal of the timbering. After much thought the idea of using asphalt was evolved, and it proved to be the material best suited for the purpose from the standpoint of effectiveness, desired flexibility, economy, ease and safety of placing.

As there was no record of asphalt having been used as a core-wall material in a dam previous to this time, The Asphalt Institute was consulted and asked to design a mixture of asphalt and aggregate which would remain permanently "rubbery" and flexible at 56 deg F, the approximate constant temperature of the earth at the depth at which the diaphragm would be buried. A flexible diaphragm would adjust itself to any of the forces caused by settlement and movement of the ground to which it might be subjected without cracking and, having this autogenous characteristic, it would seal any leaks which might occur in the future due to solution of the rock surface upon which it rested.

After experimenting with various sizes and gradings of aggregate, the Institute recommended the following specifications for asphalt and aggregate in the proportion of 11½ per cent to 88½ per cent.

(Dolomite sand was specified as it was manufactured on the job.)

Asphalt

Specific gravity	1.015
Softening point	105 deg F
Penetration (77 deg F)	190
Furol viscosity (210 deg F)	916 sec
Flash test	620 deg F

Dolomite Sand

	Per cent by weight
Passing ¼ in. retained on No. 10 sieve	19.5
Passing No. 10 sieve retained on No. 40 sieve	39.5
Passing No. 40 sieve retained on No. 100 sieve	16.5
Passing No. 100 sieve	24.5
	100.0

The placing of the mixture was very simple after the following preliminary work had been performed: A standard premix plant, such as is used for highway work, with asphalt heater, aggregate drier, batch weigher, mixer, and tanks, was set up at the site. The old wooden trench braces were removed without disturbing the sheeting and replaced with steel pipe jacks which were made in various lengths on the job. (The jacks, which were filled with cement grout to prevent the passage of water through them, were to be left in place.) The surfaces of the rock were wire brushed and primed after the trench had been thoroughly cleaned of all foreign matter.

Weighed batches of dried sand and heated asphalt were mixed for three or more minutes at an average temperature of 335 deg F and the mixture was taken in tight-bodied trucks to the trench and dumped in suitably placed hoppers which discharged vertically.

Inasmuch as the mixture stayed in a liquid or semi-liquid state for some days after it was poured, it was possible to pour the asphalt mixture at a rate governed only by the physical demands of the work. It was not necessary to limit the height of pours because of laitance formation or construction joint, as would have been the case had concrete been used. The pressure caused by the weight of the high lifts, as well as the weight of succeeding pours on the fluid mass, not only compacted the mixture in the trench but forced it into all of the surrounding spaces to the point of completely embedding the sheeting. The solution passages were so tightly packed with the asphalt that no air pockets remained

and even the small cracks in the rock were filled for some distance from the trench. This was demonstrated by a small inspection drift which was driven a short distance through the rock to a section of the completed diaphragm and also by diamond drills which later encountered stringers of the asphalt several feet from the trench.

Resistance thermometers were placed in the asphalt and a record was kept of the daily readings until the wires were lost. As the temperatures had closely approached normal by that time, no effort was made to continue the readings and the trench was back-filled with clay from the top of the aphalt to the ground surface.

In all, 4470 tons of the mixture were used in the making of the diaphragm.

Design and supervision was by American Gas & Electric Service Corp., Philip Sporn, vice-president and chief engineer, H. A. Kammer, construction engineer, F. W. Schneidenhelm, New York, consulting engineer, and the author in charge in the field.

4

BELT ELEVATORS[28]

The Elements of a Belt Elevator. A belt elevator for bulk materials consists of:

1 Buckets to contain the material
2 A belt to carry the buckets and transmit the pull
3 Means to drive the belt
4 Accessories for loading the buckets or picking up the material, for receiving the discharged material, for maintaining belt tension, and for enclosing and protecting the elevator

Kinds of Belt Elevators. Any kind of belt with buckets attached can be run around an upper pulley and a lower pulley, and it will elevate loose material. If the belt speed is high enough, the contents of the buckets will be thrown out in passing over the upper pulley (head pulley) and will fall into a chute set to clear the descending buckets, some distance below the head shaft. This is a centrifugal discharge elevator; it may be vertical, or it may stand at an angle. Vertical elevators depend entirely on the action of centrifugal force to get the material into the discharge chute and must be run at speeds relatively high. Inclined elevators with buckets spaced apart or set close together may have the discharge chute set partly under the head pulley, and since they do not

[28] Reprinted by permission, from Frederic V. Hetzel and Russell K. Albright, *Belt Conveyors and Belt Elevators*, third edition, New York, John Wiley & Sons, Inc., 1941

depend entirely on centrifugal force to put the material into the chute, the speeds may be relatively lower.

Nearly all centrifugal discharge elevators have spaced buckets with rounded bottoms; they pick up their load from a boot, a pit, or a pile of material at the foot pulley.

If the buckets are triangular in cross-section and are set close on the belt with little or no clearance between them, the machine is a continuous bucket elevator. It can be used at high speed with centrifugal discharge, as in some grain elevators, but this use is not common. The chief use of continuous bucket elevators is to carry difficult materials at slow speed. Discharge, in this case, is aided slightly by centrifugal force, the contents of each bucket pouring out over the inverted bottom of the bucket ahead of it, and into the head chute. The elevator may be vertical or inclined; to permit the buckets to be loaded directly from a chute, most elevators of this kind are inclined; very few pick up their load under the foot wheel.

Elevator Buckets. The general requirements for an elevator bucket are as follows:

1 Dimensions large enough to pick up, hold, and discharge the largest pieces of the material handled by the elevator

2 Cubic contents enough to give the required elevator capacity in pounds per minute, or tons per hour or per day, considering the speed of the belt, the bucket spacing, the regularity or irregularity of loading, and the probably incomplete filling of the buckets

3 Strength and stiffness to pick up its load without crushing or distortion

4 Thickness of metal sufficient to resist wear to an economical degree

5 Inside of bucket so shaped that material will not stick there and fail to discharge

To meet these requirements and to handle the many kinds of bulk materials, buckets for belt elevators are made in several styles:

1 Buckets with rounded bottoms, the kind generally used in centrifugal discharge elevators

2 Buckets with angular bottoms, sometimes used in high-speed centrifugal discharge elevators for grain, but more often employed in continuous bucket elevators for coarse, heavy materials

With respect to their construction and the material of which they are made, elevator buckets may be classified thus:

1 One-piece or three-piece buckets of tin plate or light-gage sheet steel, with seamed corners and reinforced by steel bands. These are used for flour-mill products and for grain.

2 One-piece buckets of heavier steel, pressed to form and riveted or welded, without reinforcing bands, used for grain and for materials heavier than grain
3 Hot-pressed or cold-pressed seamless sheet-steel buckets, used for grain and other bulk materials not too heavy
4 Cast malleable-iron buckets, for coal, ores, minerals, and other coarse, heavy materials
5 Two-piece or three-piece buckets of heavy steel plate made with angular bottoms for continuous bucket elevators

Elevator Belts. The general requirements for an elevator belt are:

1 Sufficient flexibility to wrap easily around the head and foot pulleys
2 Width enough to fasten the elevator buckets securely and to avoid twisting or turning over on the ascent
3 Thickness sufficient to transmit the working pull without excessive stretch, to back up the buckets without deflection, and to resist the tendency of the bucket bolts to pull through the belt
4 A protective cover or a body of fabric thick enough and strong enough to resist, to an economical degree, the surface wear in elevators that handle sharp, abrasive materials

Practically all elevator belts in this country are made of cotton fiber in some form; they are:

1 Rubber belts
2 Stitched canvas belts
3 Balata belts
4 Solid-woven belts

Leather makes a good elevator belt for dry work; it was in general use for that purpose up to about 1870, but now fabric belts are cheaper, more economical, and better suited to most conditions. Elevators with woven-mesh steel-wire belts have been used in Europe for light service, but they are unknown in this country. Elevators with buckets fastened to two or more parallel strands of wire rope have been tried at various times but without success.

Driving the Belt. The elevator belt is driven by the frictional contact between it and the rim of the head pulley, and since it is not possible to use a binder pulley or snub pulley against the bucket side of the belt, the angle of contact is limited to about 180°. The ability of the head pulley to drive the belt depends on the angle of belt wrap and the coefficient of friction between the belt and the pulley rim; in an elevator both of these are fixed

within certain limits, and it is not so easy to increase the driving effect as in a belt conveyor where the angle of wrap can be made larger than 180°. To get more pull in an elevator it is necessary to put tension on the belt, relatively more than in conveyors, and this leads to the use of higher unit stresses in elevator belts than in conveyor belts.

Belt elevators have been driven at the foot, but the drive is always uncertain and often troublesome.

Accessories for Loading the Buckets. In some forms of elevating and conveying apparatus it is possible to deposit separate charges or loads in consecutive buckets as they pass, by means of a mechanical loader, but at the speeds at which centrifugal discharge elevators run, that cannot be done; the material cannot be guided into a bucket moving at a rate of 3 to 10 feet per second, and the impact would scatter and spill it. At the lower speeds of continuous bucket elevators, 80 to 200 feet per minute, the difficulties of mechanical loading are less, but still serious enough to make this process expensive and troublesome. It is much easier to load continuous buckets by means of a chute, especially when the elevator is inclined, so that what one bucket misses, the next one will catch. In centrifugal discharge elevators, however, it is never possible to load buckets from a chute without spill, and it is not often attempted; it is necessary in all cases to let the buckets pick up some or all of their load as they pass around the foot wheel or as they enter the vertical run. If the elevator digs from a pit or a pile, the material is naturally confined to the path through which the buckets sweep, but otherwise a box or boot is used to form a mounting for the foot shaft and keep the material within reach of the buckets.

Belt Tension. Usually the foot-shaft bearings are adjustable in position either as take-up bearings separate from the boot or as sliding bearings which form part of the boot. Sometimes the foot-shaft bearings are fixed; then the take-up bearings are placed at the head of the elevator.

Discharge at the Head. In some forms of chain elevators the buckets discharge on the lift, but all belt elevators discharge at the head into a chute set to catch the material, either as it is thrown out by a centrifugal discharge elevator or as poured out by a continuous bucket elevator. The position of the chute and the discharge of material from the buckets depend upon three factors:

1 The speed of the belt
2 The diameter of the head pulley
3 The spacing and shape of the buckets

At the same time, the loading or pick-up at the foot depends upon:

1 The speed of the belt
2 The diameter of the foot pulley
3 The spacing and shape of the buckets

The best speeds for the pick-up and discharge of different materials have been determined by trial and experiment, and have been confirmed by years of successful practice. They agree so well with results given by analysis that it will be of interest to show how they can be established by some consideration of the theory of the subject. This discussion will at the same time serve as an introduction to the further consideration of the design and construction of belt elevators.

5

THE BAIRD CREEK BRIDGE[29]

By W. J. Ryan, M. Am. Soc. C. E.
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Loggers from the Atlantic to the Pacific have long been noted for their ingenuity in adapting local materials to any required service, and especially to bridge building. In this paper Mr. Ryan shows how the logger's ingenuity has been combined with sound engineering principles to produce an outstanding timber railroad bridge. Of unusual overall dimensions, this structure utilizes all the latest developments, such as sawn creosoted timbers, special metal connectors, concrete foundations, and design that anticipates wind stresses.

In the Douglas fir region, along the Pacific Coast in Oregon and Washington, structural material is available to the logging engineer in many forms. Decay-resistant red cedar furnishes mud blocks, piling, post, and decks for ballasted bridges. Young fir trees are available as posts or piling to lengths of 150 ft, and bridges of over 200 ft in height have been built with two decks. Sound logs of sufficient size to serve as girders are available for spans up to 80 ft and have been combined with shear connections for spans of over 100 ft. Where the logging is close to a sawmill, it is usually more satisfactory to have the timbers cut that are to be framed into a structure. This permits the use of creosoted material —important because bridges are being built for longer life.

One of the latest of these was recently completed in Cowlitz

[29] *Civil Engineering*, Vol. 11, No. 8 (August, 1941), pp. 468, 469

County, Wash., on a branch line of the Weyerhaeuser Timber Company railroad. This development is to open up timber in the Kalama River watershed, which is part of the area now planned for continuous operation to produce logs for the Longview mill. It is expected that the present cycle of cutting will require about 40 years, with the probability that after a lapse of 80 to 100 years logging will return to the same section.

The railroad was located to cross a canyon 230 ft below grade. As the canyon was occupied by a mountain stream, a 120-ft span was necessary to be safe from drift. The total length of the bridge required was 1130 ft, of which 650 ft could be constructed of standard pile trestle without exceeding a cutoff height of 90 ft. For the remaining 480 ft, it was deemed best to use creosoted timber construction.

Rock occurred near the surface on one side of the canyon and for a short distance up the other side. For about a third of the length of the framed structure, rock was too deep to be reached by excavation. Foundations were prepared by sluicing the dirt off the rock and building concrete pedestals. Where it was not practical to expose the rock, creosoted piling was driven for the foundation. The arch abutments are five pedestals connected transversely by a reinforced concrete girder, designed to carry the load of adjoining bents, so that it will be possible to use it as a footing for jacks in making repairs or adjustments.

Spanning the site was an overhead cableway 1100 ft long, used to transport all the material and equipment across the canyon. Concrete was placed by means of a bottom-dump bucket carried on this cableway. The concrete mixer was set under the approach trestle, which was driven as the first item of construction and provided bunkers for handling material to the concrete plant by gravity.

Under this cableway platforms were provided of sufficient size to allow for the assembly of the framed bents, and of the bracing in units of one span. The material was shipped from the framing yard in units and these were assembled and placed from the cableway. The bents on each side of the central arch were erected first, to the height of the arch; then the arch members were assembled in units and set in hinges at the abutments and held by guys until the pins at the center hinge were driven and sufficient bracing placed to hold them in position. The four stories above the level of the top of the arch were erected by placing first the bent and then the intermediate bracing for the length of the bridge at one elevation before starting on the story above.

Before designing the bridge, nine types of construction were considered. These are given in the following list, together with the

cost estimate for each, made on the basis of cost per square foot on the side elevation of the bridge:

1 Standard 5-pile cedar trestle with creosoted bracing and a leading bent arch over the stream $0.37
2 Standard 5-pile cedar trestle, bents on 30-ft centers, creosoted bracing 0.39
3 Creosoted 5-pile timber trestle, bents on 16-ft centers. 0.474
4 Creosoted 5-pile timber trestle, bents on 30-ft centers, arch over stream 0.457
5 Creosoted timber viaduct, with several column and truss designs for different spacings 0.516
6 Concrete and timber viaduct, with hexagonal concrete towers and creosoted timber trusses 0.712
7 Center section with concrete towers and creosoted trusses and pile trestle approaches 0.503
8 All-steel viaduct (including transportation to site) . . . 1.025
9 Center section all-steel viaduct with pile trestle approaches 0.722

After a careful study of each type of structure, considering its advantages and disadvantages, it was decided to go ahead with the erection of a creosoted timber trestle with bents on 30-ft centers, a 120-ft three-hinged arch over the creek, and pile trestle approaches.

The structure is built of Douglas fir, structural grade. The members were all framed at the sawmill and shipped to the creosoting plant, where they were given a treatment of 8 lb per cu ft of a mixture of crude oil and creosote oil for the heavy timbers, and 10 lb per cu ft for the lighter members. On its return from the creosoting plant, the material was sorted in the storage yard and loaded on cars in units for shipment to the site of the bridge. Templets were used for framing timbers. These were made from a full-scale layout. An effort was made to keep the parts of the structure uniform, but it was necessary to use well over a hundred templets. Each one of these was detailed, and drawings were made to be used by the framer and on the assembly platform.

The bridge was designed for Coopers E-55. Wind stresses, which were computed for 80-mile wind, resulted in the use of heavier timbers for the batter posts than for the intermediate posts of the bents. These bents were spaced 30 ft on centers to economize foundation costs, 30 ft being the maximum practical span for a sawn timber girder. The two outside posts of each bent were 14 by 14-in. timbers. The inside posts were 12 by 14-in. timbers. Posts were carried continuously from foundation to cap. Galvanized steel sheeting was placed between the ends of the mem-

bers and in addition a splice plate was applied to the outside.

The central span of 120 ft was made with five three-hinged arches, designed to carry the load from the five trestle bents. These arches were connected with steel gusset plates fastened to shear plates embedded in the wood, and connected at the hinges with built-up members carrying 4-in. pins. Bents were braced in the conventional manner. The longitudinal bracing between the bents was built flat and cross-braced to minimize the vibration. All the connections throughout the trestle were bolted and 4-in. split rings used except for the flat bracing on the longitudinal girts, which were spiked. Where bracing was applied to the creosoted piling it was fastened with spike grids.

The main compression joint in the arch was built by filling between two gusset plates with reinforced concrete. These joints were filled while the arch was assembled flat on the platform. This is the joint developed by John J. Gould, Assoc. M. Am. Soc. C. E., for use in the building trusses of the San Francisco Exposition buildings. Temporary bracing was placed on the side of the arch ribs while they were being picked from a horizontal position on the platform, transferred to the vertical, and placed in the structure.

In this bridge the only bearing of load on the side grain of the timber below the caps occurs at the creosoted pile foundation driven for the last four bents on the east end of the structure. There are nine piles in these bents, all capped, and on top of the caps steel channels are used to carry the posts.

Stringers consist of two chords of three members each, 12 by 31 in. These were laid level, although both ends of the framed structure are on a curve. Superelevation was taken care of by framing the ties. The framed structure carries a walkway on each side with a hand rail.

The total time consumed in the erection of the structure was 100 days after the excavation and foundation were completed. During this time the contractor had an average of 25 men employed, including the pile-driver crew. Eight men worked continuously on the pile bents, 5 men on the assembly platform, and 4 men on the erection crew, together with an engineman and helper on the crane and an engineman and signalman on the sky line.

These men were employed 21 days on the erection of the framed bents, reaching a maximum of 8 bents in place during one 8-hour shift. There were some minor delays due to errors in framing or marking the pieces as framed. A simple system of marking for such a preframed structure is vital to efficiency in handling in the material yard and on the assembly platform.

6

SYNTHETIC RUBBER[30]

by

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Mr. Chairman, Members of the Franklin Institute, and Guests: Rubber has frequently been said to be one of the most versatile of Nature's raw materials that man has pressed into his service, having in mind the wide range of properties that can be conferred upon it by compounding other materials with it and varying the conditions of vulcanization. There is no other structural material that combines the very high extensibility and almost complete elastic recovery which are the outstanding properties of soft vulcanized rubber and its synthetic counterparts. But I fear that, from the scientific point of view, rubber and synthetic rubbers are unique in another and most unfortunate respect, namely, the very high ratio of the number of words that are written and spoken about them to the amount of exact information we have concerning them—if one may speak of the ratio between quantities that cannot be expressed in the same or any definite unit. So while I am deeply appreciative of the honor which has been conferred upon me by asking me to talk to you this evening, I approach the subject with a great deal of hesitation because I fear I shall have to devote more time to telling you what we do not know than to stating facts upon which an intelligent course of action could be based.

Natural Rubber

When a shallow cut is made in the bark of certain species of tropical trees, an emulsion called latex exudes. Approximately 62 per cent of the weight of the latex is water, the exact percentage varying with the seasons, climate, and age of the trees. In 1826, that versatile scientist Michael Faraday demonstrated that approximately 90 per cent of the solids consists of a hydrocarbon having the empirical formula C_5H_8; and in 1860, Greville Williams destructively distilled rubber and produced in low yield a hydrocarbon which he called isoprene. In 1879, a Frenchman, Gustave Bouchardat, produced a substance remotely resembling natural rubber by polymerizing isoprene and postulated that natural rubber might be a polymer of isoprene.

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[30] An address delivered at the Annual Meeting of The Franklin Institute, Philadelphia, Penn., January 21, 1942. Reprinted from the *Journal of the Franklin Institute*, Vol. 233, No. 3 (March, 1942).

Chart I shows the structural formula for isoprene and the assumed structure of rubber hydrocarbon. Substantial support for this assumption has been provided by the work of later investiga-

$$\begin{array}{c} CH_3 \\ | \\ CH_2{=}C{-}CH{=}CH_2 \end{array}$$

Isoprene Monomer

polymerize to

$$\left[\begin{array}{c} CH_3 \\ | \\ {-}CH_2{-}C{=}CH{-}CH_2{-} \end{array}\right]_n$$

Natural Rubber

CHART I

tors who have identified chemical derivatives of rubber that would point to this structure. However, there is still a great deal of difference of opinion as to the value of "n" in the rubber formula, and about all that the various investigators are able to agree upon is that "n" is a large number and varies over a wide range depending upon the history of the sample under investigation.

Obviously we cannot know how Nature synthesizes rubber nor can we even be certain that her synthesis passes through the stage of monomeric isoprene. We do know a great deal about the nonhydrocarbon solids in rubber latex, which consists chiefly of sugars, proteins, and resins. We know that some of these constituents serve as protective colloids to make the emulsion a reasonably stable one and that some of the nitrogen compounds serve as antioxidants.

Derivation of Synthetic Rubbers

Although it has been more than sixty years since isoprene was first polymerized to produce a remotely rubber-like material, no one has yet been able to discover conditions for polymerizing isoprene which will yield a product that even closely approaches natural rubber in strength and elasticity. If Nature does make rubber by polymerizing isoprene, she does it in an environment that man has not been able to duplicate. Hence there is no product that can be called synthetic rubber in the strict sense of the term.

Although rubber has never been synthesized, science has found means of producing polymeric substances differing from rubber in chemical composition but approaching it in physical properties much more closely than does polymerized isoprene. These rubber-like synthetic polymers have come to be called synthetic rubbers and I will use the term in that loose sense which has now become generally accepted. Five such products are in commercial production. They are:

(1) *Polymerized Butadiene.* The structural formula of butadiene and the assumed structure of its polymers are shown in Chart II. The commercial method of polymerizing is to hold

$$CH_2=CH-CH=CH_2$$

Butadiene Monomer

polymerizes to

$$\left[-CH_2-CH=CH-CH_2-\right]_n$$

Butadiene Polymer

CHART II

butadiene at a slightly elevated temperature for a period of days in the presence of metallic sodium, which functions as a catalyst. To the best of our knowledge all of the Russian synthetic rubber is of this sort. Minor quantities of a similar product were produced in Germany before the war, but it was reported from Germany in the summer of 1939 that they had decided to drop production of this type in favor of the interpolymers of butadiene with styrene and with vinyl cyanide.

(2) *Buna S.* This product, made by the interpolymerization of butadiene and styrene (Chart III), was developed by the I. G. Farbenindustrie A.G. and has been produced by them in Germany since 1935. We believe that this product accounts for more than 90 per cent of the German synthetic rubber production. Polymerization is effected by emulsifying butadiene and styrene in water with soap or a synthetic emulsifying agent and holding the emulsion at a slightly elevated temperature for a few days. There is no substantial production of the butadiene-styrene interpolymer in the United States today, but plants are now being constructed with capital supplied by our Government, and a large expansion of

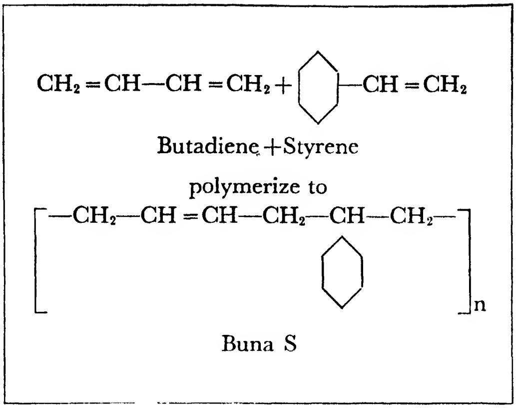


CHART III

these plants is contemplated even before the original construction has been completed.

(3) *Buna N or Perbunan.* This product, made by the interpolymerization of butadiene and vinyl cyanide (Chart IV), was also developed by the German I.G. and was first announced in 1935. Since the war broke out in Europe production has been undertaken in this country also where it is commercially sold under a variety of names, including the German name Perbunan. The various brands are not identical, differing slightly in the ratio in which the two components are present and presumably also in the nature of the emulsifying agents, polymerization catalysts, etc.

$$CH_2{=}CH{-}CH{=}CH_2 + CH_2{=}CH{-}C{\equiv}N$$

Butadiene + Vinyl Cyanide

polymerize to

$$\left[{-}CH_2{-}CH{=}CH{-}CH_2{-}\underset{\displaystyle CN}{\underset{|}{CH}}{-}CH_2{-}\right]_n$$

Buna N

CHART IV

(4) *Polysulfide Rubbers.* These products have been made commercially in the United States since 1930 by the Thiokol Cor-

poration and more recently similar products have been made in Germany. They differ from the other synthetic rubbers in that they are made not by polymerization but by the condensation broadly of an organic dihalide with sodium polysulfide. The condensation is carried out in the aqueous medium with the chlorine of the dihalide and the sodium atom of the polysulfide combining to form salt, which is removed by washing.

(5) *Neoprene.* This synthetic rubber, made by the polymerization of 2-chlorbutadiene (Chart V), was invented in the laboratories of E. I. du Pont de Nemours & Company in the late 1920's and the first plant for its commercial production was completed

$$\begin{array}{c} Cl \\ | \\ CH_2=C-CH=CH_2 \end{array}$$

Chloroprene Monomer

polymerizes to

$$\left[\begin{array}{c} Cl \\ | \\ -CH_2-C=CH-CH_2- \end{array} \right]_n$$

Neoprene

CHART V

in 1931. Chlorbutadiene, more commonly known as chloroprene, is made by the addition of hydrogen chloride to monovinylacetylene under the influence of a cuprous chloride catalyst. Monovinylacetylene is made by the condensation of two molecules of acetylene. Chloroprene is polymerized by emulsifying in water with soap or a synthetic emulsifying agent. The resultant emulsion polymerizes much more rapidly than emulsions of butadiene or the mixed emulsions of butadiene with styrene or vinyl cyanide. The time of polymerization, as with all such systems, is dependent upon the nature of the emulsifying agent and other components of the system and is normally only a few hours.

It should be pointed out that such names as neoprene, Buna S, and Buna N are in reality generic terms since there are many modifications of each of these products. Their properties may and do vary over a wide range depending upon the environment in which they are polymerized and, in the case of the Bunas, upon the ratio between the quantities of the two constituents. Poly-

merization catalysts are commonly employed which are usually oxidizing agents. When polymerization has been carried to the desired point, the emulsion is coagulated by some convenient means such as the addition of an acid or an electrolyte. Stabilizers may also be added to prevent further polymerization. A common type of stabilizer is the secondary aromatic amines.

Although only these five synthetic rubbers are actually being produced on a large scale, hundreds of other good synthetic rubbers have been produced in the laboratories of the various corporations which are working on this problem. For example, butadiene has been interpolymerized with other vinyl-substituted hydrocarbons than styrene. Methyl styrene and divinyl benzene are examples. Likewise, butadiene has been interpolymerized with chlorinated hydrocarbons, such as vinylidene chloride, and with a variety of alcohols and ethers, such as vinyl ethinyl carbinols and vinyl ethyl ether. Interesting synthetic rubbers have also been made by interpolymerizing butadiene with unsaturated ketones, for example, methyl vinyl ketone, and there are dozens of interesting products among the interpolymers of butadiene with unsaturated acids, esters, and nitriles, such as acrylic acid, methyl methacrylate, acrylic and methacrylic nitriles, alpha cyano butadiene, etc. Some of these products have shown enough promise to justify the production of a few tons of material for extended practical trials but, to the best of the author's knowledge, none of them have so far displayed a combination of physical properties, together with low cost, which would justify their commercial production in competition with the synthetics now being produced. On the other hand, there is every reason to believe that further research will teach us how to make better butadiene interpolymers and better polymers of chloroprene. The fact that so many have been tried and been found wanting does not at all mean that we have reached the end of the road.

Properties of Synthetic Rubbers

Comparison of the properties of the synthetic rubbers now being produced is made difficult by the fact that the properties of all of them are influenced to a great extent by the manner in which they are compounded and the conditions under which they are vulcanized. Moreover, as noted above, the terms Buna S, Buna N, and neoprene are generic expressions representing a class of polymers which differ greatly among themselves depending upon the proportions of the polymerizable intermediates that are used in their production and upon the polymerization environment. With these limitations in mind I shall try to describe broadly the

properties of each of the five types of synthetic rubber now being commercially produced.

The sodium polymerized butadiene polymer as made in Russia and formerly in Germany is inferior to natural rubber in practically all respects and is inferior also to the Buna S, Buna N, and neoprene types. It may safely be said that its large-scale production is possible only when it is shielded from competition with natural rubber and the other synthetics.

The Buna S type displays properties quite similar to those of natural rubber when compounded with carbon black. This ingredient is universally used in all tire tread compounds and other rubber compositions required to have high resistance to abrasion. Hence tread type compounds made from Buna S compare favorably with tread compounds made from natural rubber. However, when compounded without carbon black, Buna S is inferior to natural rubber in tensile strength and in elasticity. It would not make good rubber bands or elastic garments. Although greatly superior to the sodium polymer of butadiene, the Buna S type of synthetic rubber does not appear to have properties that would enable it to compete with natural rubber in a free market at the premium price which its higher manufacturing cost necessitates. This fact, however, does not detract from its suitability as a wartime substitute nor preclude its commercial production during times of peace if protected by an import tariff or aided by a subsidy, as has been the case in Germany.

The Buna N or Perbunan type is markedly superior to natural rubber in certain respects, especially in its resistance to deterioration by oils and solvents. By reason of its superior properties the I.G. Farbenindustrie was able before the war to produce it not only for use in their own closed economy, but also to find a substantial export market at a price several times higher than that of natural rubber. This type of synthetic rubber appears to have an attractive commercial future in specialty products where its unusual properties justify its higher cost.

The neoprenes have mechanical properties quite comparable to those of natural rubber whether vulcanized in a pure gum type of formulation or compounded with carbon black as for tire treads. They are superior to natural rubber in resistance to deterioration by sunlight, heat, and oils and also, due to their chlorine content, are relatively nonflammable. By reason of these properties they have enjoyed a sizable commercial market in the United States and abroad since 1932 in spite of the fact that they have been several times more expensive than natural rubber.

The polysulfide rubbers are superior to all the other synthetics in resistance to swelling by oils, especially by aromatic hydro-

carbons. They are also quite resistant to oxidation deterioration, which property they share with the neoprenes and the Perbunan types. However, they are quite inferior to natural rubber in tensile strength and in elastic recovery, especially at elevated temperatures. Despite these shortcomings, their excellent oil resistance has enabled them to find a substantial commercial market.

The physical properties of all synthetic rubbers and of natural rubber are greatly affected by the temperature of test. Hence, no conclusion can be reached as to the relative tensile strength, tear resistance, elastic recovery, or abrasion resistance of two or more samples without specifying the temperature of test or use. Elasticity is also a function of direction and magnitude of the distorting force, and the time cycle of distortion and recovery. A sample of neoprene, for example, may under certain test conditions be more elastic than a rubber sample of similar type and be less elastic under other conditions of test or use. The danger of allowing oneself to reach conclusions of broader scope than the range of experiments justifies is ever present in scientific and engineering investigations. This pitfall is nowhere more dangerous than in the study of the properties of rubber-like materials.

Synthetic Rubber's Uses During the Emergency

It would be foolhardy to assert that synthetic rubber can be made to serve as well as the natural product in all of the thousands of places in which our industrial and military machinery has employed natural rubber. However, we can take great comfort from the fact that during the past ten years our rubber manufacturers have adapted synthetic rubbers to thousands of uses for which they have been found to be superior to the natural product. In so doing they have acquired a background of experience that will stand them in good stead in this emergency.

During the past eight years many of our leading tire manufacturers have produced tires made wholly of neoprene and tested them under a wide variety of conditions of service with results that have been generally quite satisfactory. In addition, tires of all types and sizes have been made with a neoprene tread and a rubber carcass. These tires also have given a satisfactory account of themselves, and under some conditions of service have proved to be outstandingly superior to tires made entirely of natural rubber. During the past eighteen months one tire manufacturer has sold to the general public thousands of tires built with a tread compound reported to be made from the Buna S type of synthetic rubber and again the service experience has been quite satisfactory. All of this does not mean that our rubber manufac-

turers face an easy task. The adaptation of synthetic rubbers to purposes for which natural rubber has been used requires not only reformulation of the compounds, and modifications of processing methods, but also a careful analysis of the engineering problems involved. For example, vibration absorbing mountings for engines of trucks and other military automotive equipment and industrial machinery will present many difficult engineering problems. There is no doubt that synthetic rubber can be used, and perhaps with even better results than have been obtained in the past from the natural product, but the mechanical characteristics of the new mountings will be different and changes in dimensions and method of installation may be required in order to obtain the best results. This is only one example of the many difficult problems that a complete cessation of supplies of crude rubber would create. It is as though all sources of steel were cut off but aluminum were made available in equivalent volume. Aluminum is an excellent structural material—better than steel in many respects—but the substitutions could not be made overnight.

Synthetic Rubber Demobilized

No one can forecast what will happen to our new synthetic rubber industry when peace returns since no one can foresee the economic conditions in the post-war period. Since the industry is in the early stages of its development, it can safely be expected that the war-time plants will suffer rapid obsolescence; but if the plants we build now become obsolete, it will be because we have learned how to make better products at a lower cost. At least we shall be in a position to benefit from the great increase in our knowledge with respect to the manufacture of synthetic rubber and its practical application in our industries.

7

PLASTICS[31]

In talking to the American Society of Tool Engineers, I realize that I come to you as a specialist from one particular field of industry, and I recognize the fact that you are also specialists in an entirely different field of endeavor. We both have developed highly specialized terms and concepts. In order that we may easily understand each other, I shall try to avoid as much as possible a highly technical discussion, and I shall only try to point out a

[31] Address before the American Society of Tool Engineers, Springfield, Massachusetts, October 17, 1942, by T S Carswell, Director of Research, Monsanto Chemical Company, Plastics Division, Springfield, Massachusetts.

few of the important properties of plastics insofar as they are of interest for practical mechanical applications.

It is important to note that I would have had little to talk about even two years ago. Before the war, plastics were largely used for decorative and ornamental purposes. Their use as practical materials of construction in the mechanical field had barely started. The electrical engineer had been acquainted with plastics for quite a long time because he could make good use of their excellent insulating qualities. The mechanical engineer had made very little use of plastics, particularly because he was not very familiar with their mechanical properties. The plastics industry was probably responsible to some extent for this situation. We had not accumulated the data which the design engineer needed to evaluate the performance of these materials.

I am happy to say that the plastics industry is now fully aware of this lack of information, and rapid strides have already been made toward supplying the engineer with the design data which he needs. In my talk today, I am going to try to point out a few of the more important properties of plastics, particularly insofar as the effect of temperature is concerned.

Before going into detail, I want to point out that plastics are usually divided into two broad classifications. The first classification covers thermoplastics. As the name indicates, thermoplastics are materials which soften under the influence of heat and become sufficiently plastic so that they can be molded; they harden on cooling, and this process is reversible. This classification includes such well-known materials as polystyrene, cellulose acetate, cellulose nitrate, many of the vinyl resins, and a number of other less widely used materials. They are particularly useful in that they can be rapidly molded by injection through a heated orifice into a cold die. The cycle is very rapid, and as many as four pieces per minute may be obtained from a single die cavity. Inasmuch as an injection die usually has multiple cavities, as many as one hundred pieces per minute are often obtained.

The other classification covers the thermosetting plastics. These are materials which harden through a chemical reaction under the influence of heat, and once cured they cannot again be molded. Pressure usually has to be employed during the molding operation, because water is given off during curing. At the temperatures employed, this water would escape in the form of steam and cause bubbles and blisters if the piece were not confined under pressure. The thermosetting materials comprise such products as the phenol-aldehydes, ureas, and the newest-comer to the field—melamine resins.

A great deal could be said about the chemistry and individual

properties of these materials. However, I know that you do not have the time for a detailed discussion today, and I am therefore going to discuss only one major subject—the behavior under varying temperatures of objects molded from these different classes of materials. A discussion of the effect of temperature is particularly timely. The relation of the plastics industry to the war effort in the past year has shown that the effect of temperature is of the utmost importance in considering the usefulness of a plastic. Our armed services fully recognize this, and they usually specify that plastic parts must be operable and must retain their desirable properties over a range of temperatures from −40° F. to +160° F.

You who are tool engineers would probably not think this a wide temperature range because you are principally accustomed to working with metals, the properties of which change very little as compared to plastics over this temperature range. However, you all know that even metals do change in properties with temperature. Fig. 1 shows in a rough way the effect of temperature on the tensile properties of steel. You can see that in the range of from 0° F. to 200° F. there is virtually no change in strength. A rapid change does not take place until at about 800° F. The situation with plastics is quite different, in that plastics are quite sensitive to the temperature changes in the range from 0° F. to 200° F.

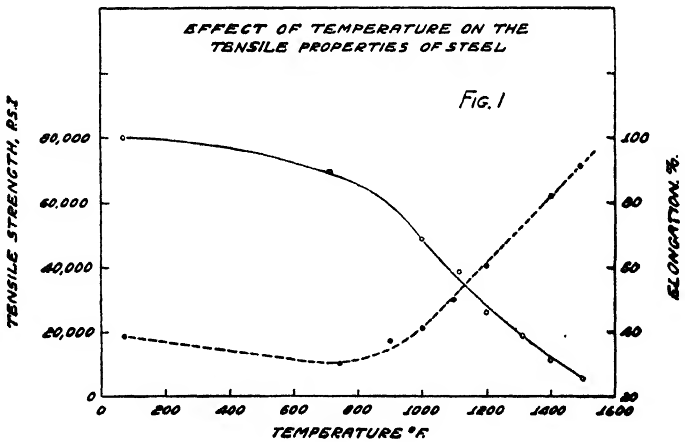
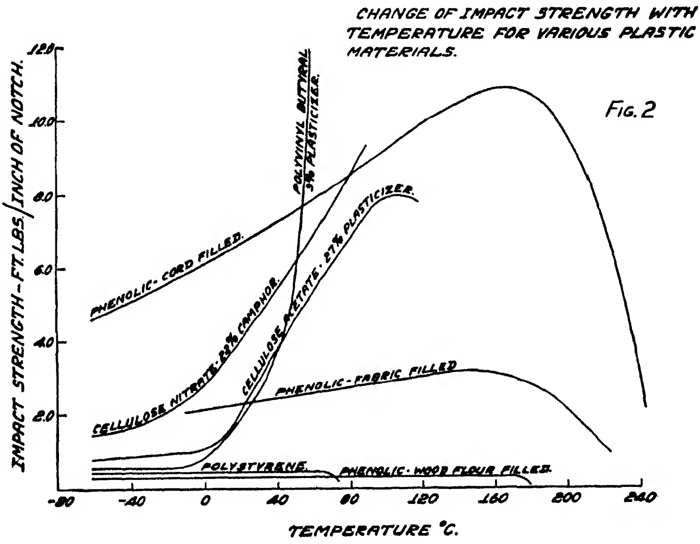


Fig. 2 shows the effect of temperature upon the impact strength of a number of plastic materials. You will note that four of these are thermoplastics—cellulose acetate, cellulose nitrate, polystyrene,

and polyvinyl butyral. As can be seen from the figure, these materials are all relatively tough at room temperature, and their toughness appears to increase as the temperature is raised, up to a certain point. Actually, this increase in toughness is only apparent, because softening sets in and makes these materials inapplicable for most practical purposes below the maximum shown in the figure. As the temperature is lowered, these materials increase in brittleness until a minimum is reached, after which the impact strength remains at a low value. It is to be noted that this minimum low value is reached at temperatures only a little below the freezing point of water.



This figure also shows impact strength as a function of temperature for three types of phenol-aldehyde molding compositions: namely, compositions which contain woodflour filler, fabric filler, and cord filler. It can be seen that the phenolic molding composition with woodflour is brittle at any temperature. However, there is virtually no change in the impact value until the temperature of nearly 160° C. is reached. The other two types of phenolic material are much tougher than the woodflour-filled. As the figure shows, they increase somewhat in toughness as the temperature is raised until a drop takes place at about 155° C. It is important to note that while these materials drop in impact strength as the temperature is lowered, the drop is by no means so sharp as in the

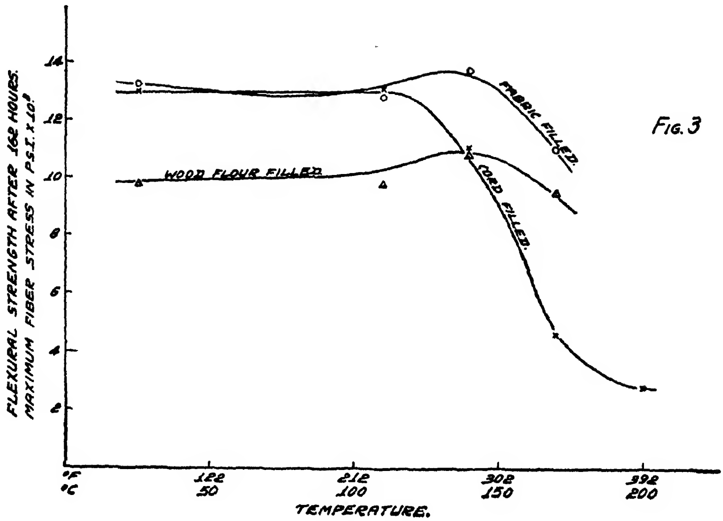

FLEXURAL STRENGTH AFTER 168 HOURS.
MAXIMUM FIBER STRESS IN P.S.I. x 10³
FABRIC FILLED.
WOOD FLOUR FILLED.
CORD FILLED.
TEMPERATURE.

FIG. 3

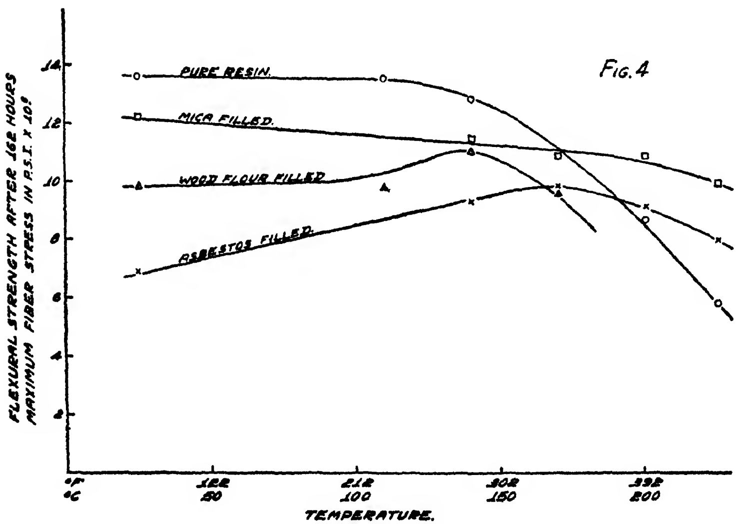

FLEXURAL STRENGTH AFTER 168 HOURS
MAXIMUM FIBER STRESS IN P.S.I. x 10³
PURE RESIN.
MICA FILLED.
WOOD FLOUR FILLED.
ASBESTOS FILLED.
TEMPERATURE.

FIG. 4

case of the thermoplastic materials. This relative lack of sensitivity to temperature is one of the important and valuable properties of thermosetting plastics.

Figs. 3 and 4 show the effect of temperature variations upon the flexural strength of various types of phenol-aldehyde molding powders. The flectural strength drops off as the temperature increases. However, as in the case of the impact strength, there is no critical point at which the properties change rapidly. It will be noted that these materials still retain most of their strength at temperatures in the neighborhood of 160° F., or about 70° C.

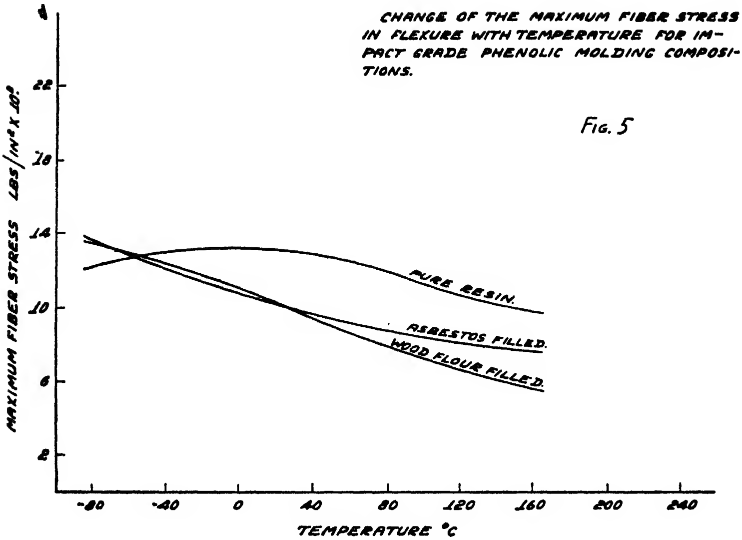
The figures previously referred to do not quite tell the whole story of the effect of temperature. The data for these figures were obtained by conditioning test specimens for about 30 minutes at the temperatures indicated. We have felt that it was important to know the effect of long continued temperature. We therefore made another series of studies in which test bars were held at elevated temperatures for long periods of time. The strength properties of the bars were then determined at room temperature.

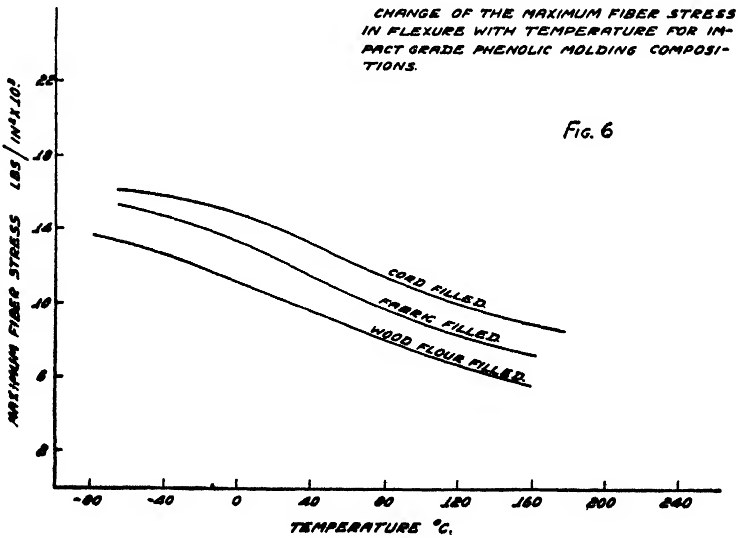
Figs. 5 and 6 show the effect of this long continued heating upon various types of phenolic molding powders. As the figures indicate, molding powders containing inorganic fillers, such as asbestos or mica, maintain, or in some cases slightly increase in strength when heated for 162 hours at temperatures as high as 200° C. The materials containing cellulosic fillers, such as fabric, cord, or woodflour, are unaffected by long heating at temperatures up to about 110° C. At temperatures over this, they begin to deterioriate rapidly, and consequently cannot be recommended for such service.

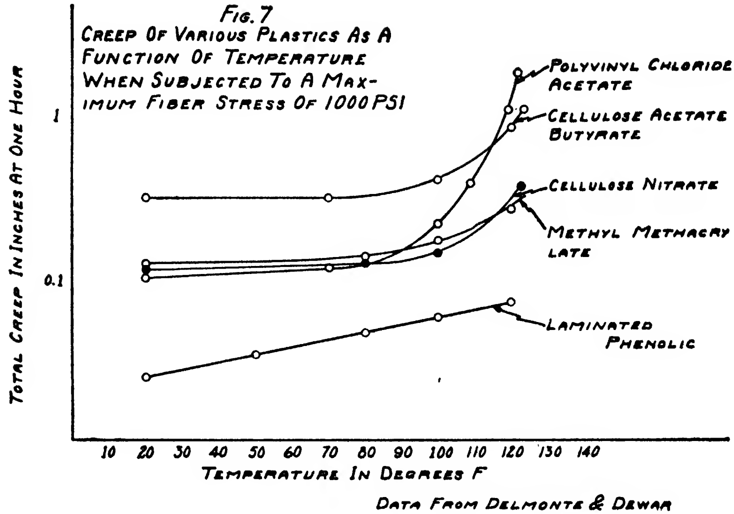
As all of you who are accustomed to dealing with metals know, creep is an important property which the design engineer must consider. Our data on creep in plastics is still rather scanty, although much work is being done in this direction.

Fig. 7 gives some creep data for a number of plastics over a range of temperatures. As you can see from the shape of the curves, the thermoplastics begin to show rapid creep at temperatures in the neighborhood of 100° F. Data for only one thermosetting material is given in this figure, and this is a laminated phenolic. The creep appears to increase as a linear function of temperature over the range studied, but in the temperature range studied there is no sudden increase in the creep rate. We now have extensive work going on to determine the effect of higher temperatures on the creep of thermosetting materials.

In this brief talk I have tried to explain a few of the effects of temperature upon the different types of plastic materials. I have not attempted to tell you how these materials may be used in


CHANGE OF THE MAXIMUM FIBER STRESS IN FLEXURE WITH TEMPERATURE FOR IMPACT GRADE PHENOLIC MOLDING COMPOSITIONS.
FIG. 5
MAXIMUM FIBER STRESS LBS/IN² X 10³
22
18
14
10
6
2
PURE RESIN.
ASBESTOS FILLED.
WOOD FLOUR FILLED.
-80
-40
0
40
80
120
160
200
240
TEMPERATURE °C


CHANGE OF THE MAXIMUM FIBER STRESS IN FLEXURE WITH TEMPERATURE FOR IMPACT GRADE PHENOLIC MOLDING COMPOSITIONS.
FIG. 6
MAXIMUM FIBER STRESS LBS/IN² X 10³
22
18
14
10
6
2
CORD FILLED.
FABRIC FILLED.
WOOD FLOUR FILLED.
-80
-40
0
40
80
120
160
200
240
TEMPERATURE °C.



your own industry. I believe that this is a question which your own imaginations will supply a better answer to. In looking over the exhibits here today, I am happy to note that Imagineering in plastics has already made a fine start in the machine tool industry. Interesting examples are the plastic body of the Van Norman cutter, a large valve handle, and numerous others. It is certainly true that plastics are coming to be more and more regarded as materials of construction, because of the advantages which they offer in quick fabrication and economical duplication where many parts are required. The war has greatly accelerated the use of plastics, and I think all of us in the industry are glad to see this trend.

Mr. Whitlock is going to talk to you about more practical aspects of molding and mold design. However, there is one thought which I want to leave in your minds because I believe there is one place where the machine tool industry can materially assist and accelerate the use of plastics, and at the same time can create new markets for both of our industries. This is in the field of mold production. The cost of a mold is very high today. If you men in the machine tool industry could develop rapid and economical methods for mold construction, the use of plastics would be greatly accelerated. Perhaps we in the plastics industry can help by developing plastics which will cure more rapidly, and which will require lower pressures. We are working to this end, and we hope that the tool designers can also help by improving and cheapening die construction.

8

WHAT WOULD COMPULSORY PATENT LICENSING MEAN TO YOU?[32]

H. V. Nye, Engineer-in-Charge, Switchgear Division
H. S. Silver, Patent Attorney, Allis-Chalmers Mfg. Co.

Congress considers legislation that might be interpreted as a limitation of free enterprise. Here are some salient facts of what compulsory patent licensing would mean to the inventor . . . to business . . . to the public.

Hearings have been held and much discussion had as to proposed congressional action[33] regarding compulsory licensing under patents. Representatives of Small Business pointed out that enactment of such a law would destroy their last fortification against being swallowed by Big Business. Big Business foresaw its utter ruination in that Small Business would obtain the benefits of the successes in its vast research and development without payment for the failures inherent in such a program. The patent attorneys were divided as to their reasons for believing compulsory licensing undesirable—some had Big Business clients; some had Small Business clients.

The wee, small voices of the two geese that lay and hatch the golden eggs of invention—the inventor and the consuming public—were unheard in the general clamor.

It is believed desirable to consider possible compulsory licensing under patents from the viewpoint of the public; for, after all, it is the public that in the final analysis foots the bill. The inventor's angle is also of interest in view of the simple fact that, no inventors—no inventions.

Assumed provisions

In order to consider generally the advantages and disadvantages of a compulsory license provision from the standpoints of inventor and public, it is desirable to start with a definite premise. We shall therefore assume that any compulsory license law would include the following provisions.

1 A non-exclusive license to be granted under any patent, independently of the desire of the patent owner, to an applicant meeting the requirements laid down by law.

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[32] Reprinted from Allis-Chalmers *Electrical Review*, September, 1940
[33] I. M Jones, "Views on Patent System Changes," Allis-Chalmers *Electrical Review*, September, 1938

2 A provision for determination of a reasonable royalty rate to be paid the patent owner for use of the invention.

3 A provision insuring adequate financial responsibility on the part of the proposed licensee.

Many other specific provisions could also be included and considered; however, they would more particularly affect the manufacturer rather than the public. Let us, therefore, consider the possible advantages and disadvantages of a license law as above outlined.

Advantages

First, the right to make use of any meritorious and valuable patented invention would be insured to the public, independently of the whim of a patent owner. Inventions of great benefit to the public could not be withheld from utilization for reasons based entirely on considerations other than that of public welfare.

For example, a washing machine for domestic use is invented, utilizing a new and improved (so far as washing machines are concerned) drier for the clothes. Two shallow basins, one inverted over the other, have their adjacent edges easily locked together by a simple movement of a locking lever. The upper basin has a sheet rubber diaphragm across it. An operating lever clutches in a small air compressor which applies pressure above the diaphragm, the compressor being automatically shut off when the pressure reaches 35 pounds per square inch. The clothes in the lower basin, whether one towel or four sheets, are pressed dry with no wear or tear on the clothes or the nerves or fingers of the operator. Movement of the locking lever toward the opening position permits the air to escape with a noise that, by its immediate cessation, indicates it is permissible to open the drier.

We can all agree that such an invention would be of great benefit to the public because of its safety features, its lack of revolving rollers or centrifugal action, and its resultant low maintenance cost and simplicity of operation. However, if a patent were adversely owned covering perhaps some single feature of the drier itself, perhaps conceived and used for an entirely different purpose, and if no license could be obtained thereunder at a reasonable royalty by a washing machine manufacturer, the public would be deprived of these greatly desirable features for the life of such patent.

It is true that it is the public that rewards the inventor by granting the right to prevent others from manufacturing, using and selling the invention, and does so in return for a published disclosure of the invention. However, this exclusive right should

not be misused so that it works injury against the grantor of such right. Compulsory license would insure against such injury.

Adequate supply assured

A second advantage of compulsory licensing would accrue from the adequate supply of a patented article. If the inventor, or one manufacturing for him, were unable to supply the existing demand or were unable to provide an increased and therefore cheaper supply, other manufacturers would be moved to take out a license and market the product.

The third advantage is perhaps of greatest interest from the public standpoint. Under the proposed law an inventor who has perfected a valuable improvement may be unable to manufacture and market such improvement because of basic patents obtained by the inventor of a device which is a commercial failure. Cases have arisen where the merits of an invention have been lost to the public merely because an invention both practical and useful could not be utilized because of a prior patent which of itself could not meet the needs of the trade. This condition has sometimes diverted the entire course of development of an art away from promising directions, all entirely to the detriment of the public.

It is true that a willing cooperation between individuals in a group of manufacturers would in some cases avoid the above condition. An example of such cooperation is seen in the automobile and aviation industries where certain classes of inventions of one manufacturer are used exclusively by him for only a short period, but are thereafter available for use by any of the other manufacturers in the group. Willing cooperation between competing manufacturers might permit standardization of certain costly parts of a device for interchangeable use by all such manufacturers, thereby permitting such parts to be manufactured cheaply enough so that their use can be universal. It is to the detriment of the public generally that similar examples of willing industrial cooperation are not more numerous.

Might increase inventor's return

A fourth advantage of the above proposed law has to do with the financial return to the inventor. As we all know, the basic price for any patent is $1,000,000.00—at least any inventor believes his invention to be worth that amount. If the royalty return in a license agreement is not commercially reasonable, the licensee will of course attempt to design away from the patent. Many

inventions are not used because of the exaggerated values put thereon by the inventor, culminating in excessive royalty rates. If the inventor were compelled to accept a reasonable royalty rate, it is believed that his return would be greater in dollars and cents than if he were permitted to grant licenses at excessive royalty rates. In other words, a reasonable royalty would stimulate use of the invention and therefore payment of royalty to the inventor.

A further advantage to the public of the proposed law is that a manufacturer would be prevented from withholding an improvement in his product merely because of the commercial advantage to him of continuing his present product. If the field of such product is controlled by patents, a manufacturer or group of manufacturers can do this. A compulsory license law as above outlined would prevent "dog in the manger" tactics.

Disadvantages

Under the proposed law an inventor would lose a part of his exclusive right, and in the case of a particularly meritorious invention he would be prevented from obtaining a financial return therefrom greatly in excess of what the law has set up as a reasonable return. The really great inventions are few and far between, and possibly the advantages to the greater number of inventors would compensate for the disadvantages to the comparatively few.

It is possible that if a patent owner were compelled to issue a license to any financially responsible applicant, such licensee would manufacture a product of such an inferior nature that it would injure the reputation of the product as manufactured and offered by the inventor. This practice perhaps would militate against the wide use and acceptance of the product and would therefore injure the inventor.

A third disadvantage might be that an inventor-manufacturer would be unable to build up a particular line through monopoly due to basic patents and improvements. While this may be a disadvantage to a particular inventor, it may be an advantage to the public generally.

A fourth disadvantage of considerable interest would be the possible loss by an inventor of control of the processes ancillary to manufacture and sale under a license. For example, the invention of irradiating milk, as covered by the Steenbock patent, is of great value to the public. The use of such invention is susceptible to considerable commercial buncombe on the part of irresponsible manufacturers and salesmen. Under the present law, the owners of Steenbock patent can control the methods of advertising and

the publicity blasts of the licensees under the Steenbock patent. Under a compulsory license law, such control might be lost to the patent owner.

Relative merits

In reviewing the above advantages and disadvantages, it appears that the advantages to be gained by the proposed law would be very desirable from the standpoint of the public. If we accept the premise that the real purpose of issuing a patent is to insure that an invention is made available to the public, the above advantages appear to be very desirable. If, at the same time, the inventor is aided in obtaining an adequate return, the public generally makes a greater gain. In considering the above disadvantages, it may be that, by suitable provisions in the proposed law, protection could be provided against improper use of the invention that might injure the reputation of the product.

Except for the possible loss of ancillary control over the licensed product, the possible disadvantages of compulsory licensing appear to be overwhelmed by the probable advantages, when considered from the standpoint of the public.

9

ENGINEERING AND ART[34]

By John Mills

[A contribution to a symposium at the Massachusetts Institute of Technology on "The Impact of Science on Art"]

Imagine a large circular table and, at its center, a man fully clothed and endowed with some elementary knowledge of mechanics. The surface of the table is ideally frictionless; it offers no footing, and the man can neither walk nor crawl across it. Faced with the necessity of getting off, he remembers Newton's third law of motion, that action and reaction are equal and opposite; that the mutual actions of two bodies are always equal and oppositely directed. So he removes one of his shoes and hurls it from him as violently as he can. The shoe travels rapidly along the polished table—that is action; and the man, much more slowly, slides in the opposite direction—there's the reaction. And it carries him over the edge of the table.

That actions occur in pairs, equal and opposite, is accepted as a law of our physical universe and finds no exceptions in chemistry or electricity. Upon its basis aviators fly and guns recoil. Does this

[34] Abridged by the author

law·hold true in the realm of mind and spirit? I would postulate that it does. In the demagogic turmoil of our world we may say that the leader is the man of the hour, an inevitable product of his time; or we may say that the leader acts on his followers but they react on him. When the nexus is less close and the spirit of the leader reaches posthumously through the printed page, then it may seem that action and reaction cannot be equal and opposite, that there is no point at which the reaction can be applied. Perhaps we arrive at too instinctive a conclusion if we think that is the case, for the dead leader leaves behind him followers, a cult or a school which bears his name. He becomes a myth and a symbol. He is incorporated. His creed becomes the charter or constitution of successive groups of followers, although some may follow from afar. And these followers are at any time the owners and defenders of the corporation, the interpreters and modifiers of its constitution. This intangible entity which has thus evolved is subject to the universal law of action and reaction.

In the impact of imponderables—of civilization and barbarism, of science and religion, or of science and art—there is no action unaccompanied by an equal reaction. So closely paired are action and reaction in the physical world that sometimes the action is to be recognized or measured only by the reaction. In our muscular experiences we are usually conscious of action, of exerting a force, only insofar as we experience the reaction. Recall the relative sensations of throwing a bowling ball, a baseball, and a ping-pong ball and one arrives at the necessary conclusion that reaction is the muscular evidence of action. Probably no creative artist would contend that his spiritual actions are unaccompanied by equal reactions. When in the crowd the woman touched the hem of his coat, it was not without justification that Jesus said: "I perceive that virtue is gone out of me."

So far I progressed in what you might call an engineering attack on the problem presented by the impact of science on art; then I was stopped—to be honest, I was stumped—by my inability to recognize any reaction of art upon science. I could cite reactions upon science of religion, of machine industry, and of social philosophies. But of any reaction upon science, in the sense in which I was interpreting those words, I was unable to detect a trace. And so I turned to reconsider the pregnant words in which is phrased our subject: the impact of science on art. We have here three short Latin words, all of long life and two of continuous evolution; words which we bandy back and forth, each assuming that the other knows what we mean. So before we can proceed, we need to agree for the moment on our definitions. It helps but little to qualify our terms by calling art either fine

or useful and by calling science either pure or applied. For myself, I cannot separate the livability of a house from the emotional and esthetic satisfaction which it affords its occupant. The pure science of today is the applied science of tomorrow; at least, the applied of today was pure yesterday.

To limit our terms, let us distinguish, for example, between art and artists—between a body of attitudes, principles, and techniques and any individual or all who adopt those attitudes, practice the principles, and apply the techniques. That is not to say that art is independent of artists but rather that the whole is greater than its parts and that art transcends artists as science transcends its adherents and proponents. Now having separated artists from their art, let us next distinguish between art which finds its embodiment in unique products and that which feeds the machine industry and appears in a myriad of facsimiles. The distinction may seem academic: It may seem that there are not two kinds of art but merely a difference in medium; that working in one, the artist leaves a monument in eternal bronze and in the other, a hundred thousand plastic replicas. Much of the effect, however, which science has had upon art is due probably to the possibility of quantity production.

Within science, on the other hand, some differentiation should be made, for example, first as a manner of thought and a method of attack; second, as a rapidly growing body of knowledge; and third, as the basis of the engineering arts through which it supplies the products and facilities of our material civilization. Let me emphasize those aspects of science: its methods; its data, laws, and working hypotheses; and, last, its engineering applications. Stripped to essentials, what we glibly call the method of science is a process of controlled experimentation whereby can be derived a quantitative relationship between the variables in a physical phenomenon. The experimenter varies only one condition at a time in order to be able to say: "Other things being equal," a change of so much produces such an amount of effect. Only under those conditions does he assume to draw a valid conclusion.

Science as a manner of thought has little effect, if any, upon art with a capital A, the art which is concerned with unique products. That is not true of art which feeds the machine. Usually when an industrial artist designs for the machine, he must cooperate with engineers and is thus exposed to the scientific method. How far that method is applied depends, of course, upon the thing which is being designed. A pattern for textiles, all so-called novelties, most boxes and bottles which lure purchasers, and a myriad of other products reproduced by the machine—

none of these requires of its artist even a vague sympathy for scientific method. When, however, the product is itself a machine, an electric razor or a telephone set, then appearance must be subordinate to function. Something must be known about each variable—electrical, mechanical, or artistic—which enters into the design. Function, reliability, accessibility for maintenance, useful life and appearance, all these requirements of the customer are implicit functions of many variables. And so is the requirement peculiar to the producer, that is, economy of manufacture both in process and in raw materials.

The extent to which the industrial artist brings the scientific method to bear upon his coordinate portion of a design problem depends also upon the extent to which the company for which he designs has itself a scientific attitude. When artist and engineer cooperate in a scientifically minded industry, there is an impact, and the reaction can be observed. In those industries the design engineers, mechanical and electrical, are quickened into an artistic consciousness. To their technical criteria they add those of art. The operation is one of addition not of alteration, for neither art nor science sacrifices or modifies its attitude. Each is broadened by an appreciation of the standards and methods of the other. Such a combination of art and science is not a new phenomenon. We have had it for years in architecture.

Turning now to the second aspect of science, its laws and data, there is little reason to expect much effect on the attitudes and principles which we include under the term art. Upon artists their effect is probably the same as upon laymen in general. The laws of science, when known, are accepted like the calendar—an inevitability for which one must allow. Its data are accepted uncritically, utilized when need and knowledge happen to be contemporaneous, but frequently misinterpreted. All in all, I am afraid, the scientific knowledge of the artist, even more than of most men, is a hodgepodge of fact and fancy. He has a vague respect for science, credits it with much of the world in which he lives, but belittles and sometimes fears its possible effects upon his art.

Except in those infrequent occasions when the artist reacts violently against his environment, he accepts, like the rest of us, the facilities which applied science provides: the rapidity and ease of transportation, whether of goods, men, or ideas; all the creature comforts of protection from the elements; and the conveniences of controllable sources of light, heat, and power. Like the rest of us, his life is conditioned by machines which gradually but inevitably affect emotion and thought on matters social or political and religious, philosophic or artistic.

And so we come to the impact upon art of science in its third aspect, the facilities provided through the engineering arts. And here I may do an injustice to science or art, one or both. Imagine the artists of a primitive people. Their art cannot exceed their experiences nor can it be produced in mediums not available in their surroundings and their technological state. Through slow and uncontested migration they reach a new area, richer in the materials of art; new colors and new mediums are available; and new forms are suggested by their surroundings—snow-clad peaks, deep gorges, lush valleys but stunted trees around their rim—a different face to nature. Their art in time will utilize the new materials and reflect the new environment. That, to my mind, is about what has happened to art through the applications of science. There are more materials at its disposal, new objects to adopt into its symbolism, and strange activities to be reflected by the observant artist. Above all there are new habits to be formed and new rituals to be met, but these they share in common with the inartistic.

The architect some years ago began to build in steel, long after steel became one of the mediums available. Was it his art and aspirations that carried structures higher and made walls thinner? Or was it because of ground rents and the congestion which elevators and telephones made possible and profitable? He supplemented with reinforced concrete, an environmental necessity in a country rapidly denuded of its forests. New art forms, however, did arise from new materials. Today, it would seem, the course of his experimentation is accelerated as more and more new materials stream from manufacturers' laboratories.

Music furnishes another illustration of new instrumentalities made possible by applied science. But the illustration is essentially negative since so far the effect of radio broadcasting, sound motion pictures, and improved phonographs seem to be an economic one on musicians rather than upon their art. Greater rewards and larger audiences for the more successful, at least.

Music illustrates the future effect upon art of new scientific techniques, whereas architecture illustrates the continuing effect of new materials. Painting, on the other hand, and its teeming sisters of the graphic arts illustrate the adoption of new objects into symbolism. In literature and especially in drama we find reflections by the observant of new activities which the engineering arts have made habitual. The machines of today are prominent in the material and symbolism of literature. Poetry also derives from its present. Not only the instrumentalities but also the facts of science are utilized in literature. One can hardly read a new detective story without acquiring unimportant data of science.

What Freud started in the terminology of the unconscious has served many a novelist in good stead. To literature, science contributes facts, laws, and theories; but I do not see that they have had more than a surface effect upon the art itself.

Dominant over all in its effects upon the fine arts, it seems to me, is the tempo of our times—what Walter Gropius has called "the rush and convulsion of our mechanical age." To this tempo the machine of applied science has contributed, but the machine is far from uniquely to blame.

Exercises

A Write editorials, one, two, or more paragraphs in length, commenting on:

1 An article in a technical journal
2 Some public question which involves engineering practice
3 A certain method of work or a discussion in a textbook of a technical point
4 The death of a well-known engineer
5 A great engineering enterprise of special interest to the public.

B Write an abstract or summary of the contents of a book or an article, *e.g.*, of any one of the articles in this chapter.

C Write a definition of any one of the following terms:

Magnetism	Voltage
Dry kiln	Water rights
Impedance	Hysteresis loss
Dielectric	Combustion
Oscillatory-current waves	Force
Induction	Energy
Railway reconnaissance	Charging and discharging
Power factor	Core loss
Engineering location	Potential
Rotor	Contours
Horsepower	Photometry
Insulation	Eddy currents

D Write an explanation of one of the following things:

1 A simple instrument, piece of apparatus, or mechanism
2 The merits of a piece of construction
3 Plans or methods of proposed work
4 A drawing

5 A piece of engineering work which you have seen
6 An engineering project which has been described at length in the technical journals

E Write a brief exposition of one of the following processes:

1 Surveying by stadia method
2 Lubricating combustion engines
3 Setting up a mold
4 Cleaning and grinding valves
5 Preparation of sodium
6 Making a foundry pattern
7 Measuring resistance
8 Making sepia prints
9 Use of the compass
10 Surveying a mountain farm
11 Establishing a base line measurement
12 The treatment of a certain ore
13 A blowpipe analysis of ———
14 How to make a septic tank

F Write a review of a book.

G Compose a paper for an engineering society upon some original work being done in the laboratory, shop, or classroom.

H Revise a section of poor English from a technical book or journal.

I Write an argument for or against one of the following things:

1 The use of certain materials
2 Scientific management
3 A certain type of apparatus
4 A particular type of construction
5 The placing of certain clauses in certain documents
6 Enlarging a plant, or for or against specific methods of enlarging the plant
7 The use of certain business methods: for instance, argument in favor of establishing a sinking fund or of expanding a plant
8 The employment of certain kinds of labor

J Write a piece of argumentation, giving in condensed form the main points of contrasted methods or machines, points which the student may obtain from wide reading on a particular subject. The examples are merely suggestive:

1 A comparison between fire-tube and water-tube boilers, touching on essential differences in construction, differences in time of steaming, safety, economy
2 An explanation of the piece-work and hour system, followed by a statement showing which, in the opinion of the student, is the more economical to the manufacturer, and the more satisfactory to the employee

K Write a popular account of a technical subject for a layman.

L Write a semitechnical account of an engineering problem and its solution.

M Write a lengthy article on any one of the following topics:

1 The construction of small wood-truss bridges
2 The irrigation of small farms
3 The operation of the bucket-type dredge
4 Construction of concrete culverts for highways
5 The use of wood pipe for water supply
6 Concrete piles
7 Wooden piles
8 The placing of bitulithic pavement
9 The placing of concrete pavement
10 Structural qualities of steel
11 The electrification of railways
12 The surveying camera
13 The operation of the suction dredge
14 Waterproofing concrete
15 Modern excavating machinery
16 The modern paving machine
17 The importance of the lumber supply to construction
18 The application of electric heating devices in the industries
19 Lighting intensities suitable for various kinds of work
20 The amortisseur winding and its influence upon the field of application of the synchronous motor
21 Electric ship propulsion
22 Limits to the development of water power in this state
23 The extension of electrical service to the farms and rural districts
24 Logging by electrical power
25 The relation of the public service corporations to the consumer
26 The development of the art of illumination
27 Trunk-line electrification
28 The development of electrical measuring instruments
29 The moving coil or D'Arsonval galvanometer

30 The electrodynamometer principle voltmeter
31 The measurement of resistance
32 The transformer
33 Magnetic properties of iron and steel
34 The use of the electromagnet in handling materials
35 The development of the lead-acid battery
36 Modern uses of the storage battery
37 The use of synchronous motors for power-factor correction
38 Different methods of synchronizing alternators
39 The use of regenerative braking on railways
40 Modern facilities for light projection
41 The three-wire generator
42 Electricity for paper-mill drive
43 Privately owned power systems vs municipal systems
44 The conservation of fuel by hydroelectric development
45 The development of high-voltage insulation
46 The development of the steam boiler
47 The development of the airplane
48 The Diesel engine in marine service
49 The steam turbine in the modern central station
50 The steam turbine for ship propulsion
51 The development of the locomotive

N Discuss desirable characteristics of advertising pages in technical magazines—according to the following suggested items:

1 Layout that will attract attention
2 Ease of recognizing at once important features of advertisement
3 Adequate illustration
4 Clear-cut emphatic statements as to good qualities of product
5 Simplicity, conciseness, and brevity of text
6 Proper subordination of explanatory details to main features
7 Dignity
8 Pleasing variety of type forms
9 Prominence of name and address of firm

O Practice the expression in words of the meaning of an equation. Study the following examples.

1 The equation

$$dw = P\,dV$$

expresses the fact that the infinitesimal increase in work dw performed by a substance on differential expansion is equal to the product of the pressure P and the infinitesimal increment of volume dV through which the substance expands.

2 The equation

$$w = \int_{V_1}^{V_2} P\, dV$$

means that the total work, w, performed by a substance on expanding from the initial volume V_1 to the final volume V_2 is equal to the integral, or summation, of all the infinitesimal increments of volume dV at the instantaneous pressure P between the limits V_1 and V_2.

3 The differential equation

$$dE = \left(\frac{\delta E}{\delta P}\right)_T dP + \left(\frac{\delta E}{\delta T}\right)_P dT$$

states that an infinitesimal increase in energy, represented by the differential dE, equals the rate of change of energy with pressure at constant temperature, $\left(\frac{\delta E}{\delta P}\right)_T$, multiplied by the change in pressure dP, plus the rate of change of energy with temperature at constant pressure, $\left(\frac{\delta E}{\delta T}\right)_P$, multiplied by the change in temperature dT.

4 $E_1 = 1 - \dfrac{Tc - Td}{Tb - Ta}$

The efficiency is equal to unity minus the ratio between the difference in absolute temperature at points c and d and the difference in absolute temperature at points b and a.

5 $I = \int y^2\, dA$

I is the moment of inertia of an area with respect to some axis and y is the distance of a differential area dA from the axis.

Statement: The moment of inertia of an area with respect to any axis is equal to the sum of the products formed by multiplying each differential area by the square of its distance from the same axis.

6 $\frac{T_1}{T_2} = e^{fB}$ in which T_1 is the tension on the tight side of a belt, T_2 is the tension on the loose side; $e = 2.718$; f is the coefficient of friction between the belt and pulley and B is the angle (in radians) of contact of the belt.

Statement: The ratio of the tension on the tight side of a belt to that on the loose side is equal to 2.718 raised to a power which is equal to the product of the coefficient of friction and the angle of contact.

CHAPTER 7

Bulletins, Booklets, Catalogs

THE PREPARATION of such occasional publications as bulletins, booklets, and catalogs constitutes an important part of the technical writing done by engineers in the service of the larger engineering manufacturing companies. Many firms issue bulletins more or less regularly, containing technical articles of interest to their clients and perhaps to the general public. Whether published at stated intervals or not, bulletins are regarded as belonging to a series; hence, it is desirable that the members of a given series possess some uniformity of style, make-up, and purpose. If the subjects treated are widely diversified, however, the bulletins may bear to one another no more than a family resemblance.

Booklets, on the other hand, attempt no uniformity of treatment and are not ordinarily published at regular intervals. They are usually issued to meet some special requirement: to describe a new mechanism or process, to explain the application of laboratory research, to give instructions for the operation of apparatus, to narrate the accomplishment of an important engineering project. They range in size from the merest brochure or pamphlet of four pages to the impressive publication of many pages with copious illustrations and charts.

Catalogs, finally, are a special type of booklet marked by a single, definite purpose: to present in compact, convenient, logical listing, with or without prices, the products of a manufacturer. Insofar as the items require detailed description and explanation, catalogs fall under the head of technical writing.

For the sake of brevity, the word "bulletin" will be used in this section to indicate all occasional publications referred to by the longer heading, "Bulletins, Booklets, and Catalogs."[1]

[1] Excluded from the following treatment are three types of publications: (1) advertising matter which has a direct sales appeal and is, therefore, primarily the concern of the sales or advertising department and not of the engineering division. Under this head are advertising pamphlets in which the technical element is distinctly subordinated to the sales element, and catalogs which enumerate mainly items and prices; (2) house journals of regular issue; (3) reprints of technical articles in booklet form. This practice of reprinting articles is far from occasional among manufacturing firms; *e.g.*, *Centrifugal Boiler Feed Pumps for High Pressures*, reprinted from *Combustion*, May, 1935—De Laval Steam Turbine Co.

Character of Bulletins

The character of a bulletin is determined by the class of readers for which it is prepared—specialists, engineers in general, or the lay public.

Technical bulletins. The strictly technical bulletin deals ordinarily with subjects in highly specialized fields of knowledge and is aimed at an audience of experts. No concessions are asked or given in addressing such an audience; a thorough knowledge of basic principles and specialized terminology may be taken for granted.[2] At the same time, however, if the subject is novel or previously unexploited, there may be point in a brief introduction and a historical review of earlier studies.[3] The body of the bulletin must be well ordered, compact, and scientifically explicit. Hazy phraseology, uncertain statements, guesswork are not admissible. The tone of the bulletin should be sure, definite. Add to this a dignified style, and the bulletin achieves the effect which is of the highest importance—authoritativeness. Direct reference to the commercial aspects of the subject under discussion is usually avoided. Aids to convenient reading and reference, such as marginal headings and tabular enumerations, are used when necessary. Illustrations, graphs, and drawings usually accompany the text.

Semi-technical bulletins. Bulletins designed for the general engineering "audience" cannot be over-technical in dealing with specialized matter. Most engineers have a general knowledge of all branches of their profession together with a specialized knowledge of one or more of its many divisions; a specialized knowledge of all divisions is, of course, not to be expected. Therefore it is only reasonable, in writing a bulletin for wide circulation among technical readers, to make some concessions. Too great a knowledge of technical terms should not be taken for granted. All unusual terms should be defined and unusual pieces of apparatus described. Illustrations, graphs, etc, should be used when necessary, but only as supplementary to the text.

Under this heading occur such publications as instruction booklets and catalogs. In the writing of instructions, clearness is the first essential. Each direction must mean one thing,

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[2] An example is the Babcock & Wilcox *Integral-Furnace Boiler* (Bulletin G-17-A).
[3] An example is the De Laval *Single Suction Multistage Pumps* (Catalog B-5).

and one alone. Judgment must be used to decide just how much technical knowledge of the subject can be assumed on the part of the reader, and talking down to him must be avoided equally with talking over his head. No general direction for the making of technical catalogs may be given beyond the statement that a catalog, apart from its sales value, is a reference work and should therefore present its information with a view to maximum accessibility. Items are arranged alphabetically if possible. Where this order is impracticable, some other logical scheme is used in conjunction with an index. Illustrations are lavishly supplied. The text is descriptive or explanatory of the illustrations; it must be as brief as possible and closely combined with the illustrations to which it refers.[4]

Non-technical bulletins. As part of the publicity programs of larger technical organizations, a wide variety of bulletins is issued for the information and education of the lay public. The weekly educational broadcasts of one of the largest American manufacturers of electrical equipment are proof that such publicity is considered worth while for its dividends of good will and intelligent understanding. In writing for the layman it is useful to remember what Huxley called his famous scientific lectures to London workingmen. They were "people's" lectures, never "popular" lectures. In other words, Huxley simplified his presentation to fit the understanding of his hearers, but never by condescending to them or by cheapening himself or his message.

Among the publications included in this division are the simpler types of instruction booklets and catalogs as well as the vast variety of informational and educational pamphlets. In all of these there is, of course, no objection to some degree of commercial appeal, but it should be so skillfully worked into the text as to be quite subordinate to the main purpose of the bulletin.[5]

A good non-technical (or "people's") bulletin differs not at all from the technical or the semi-technical bulletin in its faithfulness to scientific truth. Behind the studied simplicity of the text must lie the same complete and thorough mastery

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[4] As illustrative may be cited the Allis-Chalmers *Transformer Reference Book* (B6117) and the Babcock & Wilcox *Condensed Catalog* (G-2-B).

[5] Illustrative of this type of bulletin are the Westinghouse *Pyramids to Paper* and the General Electric *Thus Spake Haroun-al-Rashid.*

of the data which is more obviously employed in the more technical presentations. The style is different. Simple, everyday words; simple sentences; short, compact paragraphs—these form the groundwork on which a clever writer can build an informal, conversational style. If he can inject an occasional touch of personality, so much the better. Even human interest is not out of place and may often be worked into illustrations as well as text. Simple pictures and diagrams are used in close relation to the text. Simple headings in bold face type emphasize the successive stages of the thought development. In short, no pains should be spared to make the non-technical bulletin easy, pleasant, readable.

In a booklet entitled *Technical Writing* (1941), Richards and Richardson of the Research Laboratories of the General Motors Corporation relate a good story about the importance of non-technical bulletins in the general business of manufacturing. Acting on the conviction that automobile owners are interested not only in the appearance and operation of a car from the driver's seat but also in what goes on under the hood, General Motors several years ago prepared a booklet entitled "Chemistry and Wheels." It aimed solely at building good will. In its preparation certain guiding rules had to be kept in mind. It had to be in simple, understandable language, and also accurate. It had to be interesting. It had to avoid any definite sales urge. The favorable response was overwhelming. Since then six similar booklets have been prepared. The distribution has amounted to 2,500,000 copies a year, the booklets being sent out only on written request.

Make-up of Bulletins

The physical make-up of the bulletin demands particular consideration. Whether or not it is to make a direct sales appeal, it ought to make a good impression; its appearance should be worthy of its contents. Make-up is not only a matter of attractiveness but much more a matter of convenience. The reader's approach to the facts must be made easy, both in seeming and actuality. However good in substance, advertising matter falls short of its intended effect if it is unattractively presented. Sometimes too little thought is given to the very real element of esthetic appeal. In bulletins, this appeal is compounded of novelty and good taste. Some originality of appearance is

desirable to catch the attention of the reader. No reader is attracted by a pamphlet which repeats, with depressing faithfulness, the dullness and stodginess of its uninspired predecessors. On the other hand, most readers are justifiably suspicious of a cheap and flashily dressed publication. Certainly in the technical and the semi-technical bulletins, dignity is more important than novelty. But good judgment will always seek to effect a synthesis of both qualities.

"Leave all that to the printer" is a risky policy, unless your printer has had exceptional experience in handling publicity matter of a technical nature. In consultation with him, decide on the size of booklet, number of pages, quality of paper, sizes and kinds of type for titles, headings, and text, arrangement of the page, width of margins, placing of cuts and tabular matter, cover design, and any other details in which you expect him to be guided by your wishes.[6] Having described your idea of the job as fully as may be, you can safely trust the rest to the printer's judgment, subject to the further checks of galley and page proof.[7]

Headings. Most common of the devices which enhance the appearance and the usability of the bulletin are headings. Separated from the text, the headings should resemble an outline of the bulletin, the main headings corresponding to outline topics of the first order, subheadings corresponding to outline topics of the second order, and so forth. Whether the headings follow an outline closely or only approximately, they must indicate clearly the logical relation of the parts of the text. Headings should be cunningly phrased to say as much as possible in the briefest and plainest fashion. The heading writer might borrow some ideas from the technic of the headline writer on a first-class newspaper.

Main headings are usually centered and printed in larger or heavier type than the body of the text. Subheadings may also be centered if a less conspicuous type is used for them. Or they may be printed as the first words of a paragraph, using boldface or italics to distinguish them from the rest of the paragraph. For sub-subheadings, which usually refer to a single paragraph

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[6] It is now fairly easy to obtain reliable guidance on typography; *e.g.*, Exhibits of the American Institute of Graphic Arts, articles in *Publisher's Weekly, Book Binding and Book Production*, etc.

[7] For preparation of manuscript and correction of proof, see Appendix A.

only, the best place is the margin if, by using small type, they can be placed there without crowding. If the margin is not wide enough, they may be blocked into the body of the paragraph by indenting a sufficient number of lines of the text.

Tabulation. When masses of figures and other data are to be displayed for the purpose of emphasis, contrast, comparison, or condensation, thought should be given to the devising of the most effective tabular arrangement. Special type and generous spacing will help to convey the purpose and meaning of the table at a glance. The following full-page display illustrates the skillful use of both headings and tabulation. Note the incidental economy in textual matter, a saving of no slight importance.

ECONOMIC ASPECT OF A 200-TON SULZER PLANT[8]

Daily Savings

Value of steam generated

At a steam production of 850 lb per ton of coke, and a price of 50 cents per thousand lb of steam, the value of the steam generated with the sensible heat of glowing coke amounts to $200 \times \frac{850}{1000} \times \$0.50 =$ ......\$ 85.00

Reduction in the amount of coke breeze

A reduction in the amount of coke breeze of 1% of the total coke production, a price of \$10 for coarse coke and \$4 for breeze may be assumed. The saving therefore amounts to $0.01 \times 200 \times (\$10 - \$4) =$ 12.00

Increased value of dry coke

Due to absence of water, the increase of calorific value of the dry coke is equal to a fuel saving of about 1%. Therefore the selling price of dry coke can be increased by about 1%, the gain amounting to $200 \times 0.01 \times \$10 =$ 20.00

Total daily savings..............................\$117.00

[8] Taken from Catalog DQ-2, Dry Quenching Equipment Corporation

OPERATING COSTS	
Electric energy	
for fans and hoist with a price for current of 1 cent per kwhr.	$6.00
Labor	
In addition to the labor employed for wet quenching, ½ time for one man per shift, at a shift wage of $6.00.	9.00
Maintenance and repairs	
Costs for maintenance and repairs assumed as not higher than with wet quenching.	
The cost of boiler feed water is not considered herein since it is well balanced against the cost of water used for wet quenching.	
Total daily operating costs	$15.00
TOTAL NET SAVINGS PER DAY	$102.00
Total Annual Savings (based on 350 working days)	*$35,700.00*

Enumeration. When a series of statements of the same general order is to be presented, the several statements should be numbered and listed. Often it is desirable to display the enumeration by blocking it in the center of the page. Each item in the enumeration should be precisely phrased, and should be strictly parallel in structure with every other item. Any violation of parallelism impairs the logical structure of the whole enumeration and hinders that immediacy of communication which the device is meant to facilitate. An example of parallel enumeration follows.

Permissible explosive is a name which is accorded to certain explosives by the United States Bureau of Mines. The Bureau of Mines defines a permissible explosive as an explosive which has passed certain tests by the Bureau to determine its safety for use in coal mines and which is used in accordance with the conditions prescribed by the Bureau.

The conditions specifically prescribed by the Bureau are as follows:

1 That the explosive shall be in all respects similar to the sample submitted by the manufacturer for test.

2 That an electric detonator shall be used of not less efficiency than those prescribed; namely, no. 6, consisting

by weight of 80 parts of mercury fulminate and 20 parts of potassium chlorate (or their equivalents).

3 That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use.

4 That the quantity used for a shot shall not exceed 1½ pounds and that it shall be properly confined with clay or other non-combustible stemming.

Illustrations and graphic devices. Photographs and drawings are more lavishly used in bulletins than in any other type of mechanical writing. Especially in catalogs and in booklets for the non-technical reader, illustrations must be provided in abundance. They should be prepared with care. Only clear photographs which will reproduce well should be used. Drawings should be lettered when reference to parts is necessary. The connection between illustrations and text should be absolutely clear.

To the trained reader a graph often means more than a picture, a curve more than a page of text. Even to the untrained reader, the simpler types of graph are useful for purposes of comparison and relationship, and may even enable him to grasp ideas which the text alone cannot make clear. The use of graphic devices may also effect an economy of space. To realize the service of illustrations, graphs, and charts in clarifying and reinforcing textual matter, the student should study the bulletins which are generously supplied to technical schools by all manufacturing companies.

Annotated List

For specimens of various kinds of bulletins, the interested reader must resort to a personal examination of such publications. The college student, to whom this book is particularly addressed, will have ready access to current bulletins as they are received and, perhaps, filed in the offices or libraries of technical schools. All manufacturing companies, practically, issue many bulletins. The difficulty for the student will be largely in selection. To aid him somewhat, an attempt is made here to indicate some of the characteristics of well-written bulletins of various kinds. For practical purposes, the simple division into technical, semi-technical, and non-technical bulletins is expanded and made more specific. References to

typical bulletins will thus appear under the following headings:[9]

Technical exposition
Narrative (including historical) or descriptive exposition
Discussion
Instruction
Popular
Catalog
Pictorial

These divisions are not mutually exclusive. They serve only for purposes of study and of practice in writing.

TECHNICAL EXPOSITION

The Frick Blizzard Freezer—a four-page folder; compact; paragraph explanations with no headings, accompanied by simple, practical illustrations. Frick Company.

Ice and Frost—a more elaborate expository bulletin from the same firm, characterized by prominent section headings in red ink, short paragraphs, completely constructed sentences, pictorial and graphical illustrations.

Distribution Transformers—a 24-page bulletin, the distinctive feature of which is the effective use of arrows to connect text with illustrations. General Electric.

Turbine Generators—a 78-page bulletin from the same company, with elaborate illustrations combining both technical and human appeal, brief textual comments, variety of sheet color, ample space for both text and illustration.

Single Suction Multistage Pumps—after an introductory section summarizing in boldface type the distinctive features, the bulletin proceeds with a compact discussion of each feature in large, easy-to-read type, the text supported by a series of illustrations which show with remarkable fidelity the details of operation. De Laval Steam Turbine Company.

Integral-Furnace Boiler—an effective, pleasing combination of color, spacing, type, exact photographic reproductions, and neat diagrams, with a summary of distinctive features on the last page. The Babcock & Wilcox Company.

Copper Tubes & Fittings for Industrial Applications—a 64-page bulletin, combining catalog, discussion, and instruction

[9] The student will of course supplement the following brief list of typical bulletins by an examination of similar publications. It is not to be inferred that the specimens to which reference is made in this chapter are better than innumerable other bulletins which are prepared and distributed by companies not here mentioned. The present selection is almost arbitrary.

features; effective contrast between copper color for pipes in illustrations and blue color for marginal headings and for margins in illustrations. The American Brass Company.

Economical Power—a bulletin which sets forth in a dignified form the applications of turbines to the varying requirements of industry; short, compact paragraphs discussing kinds of turbines and features of construction; pleasing arrangement of center headings and effective use of colors in large illustrations. Westinghouse.

NARRATIVE OR DESCRIPTIVE EXPOSITION

Alnico Magnet—a bulletin which, as illustrated by the subtitle, the Story of the New Damping Magnet for G-E Watthour Meters, is concerned mainly with the story of how this magnet is made. A section at the end presents the historical development of watthour meter design from 1889 to the present by means of simple illustrations and brief textual comment. General Electric.

Building Modern Motor Power—a semi-technical or perhaps non-technical bulletin; after a brief historical résumé, the bulletin presents its story mainly by the use of human-interest pictures which show the stages in the construction of motors; it concludes with a section on service. Westinghouse.

Camphor Becomes an All-American Industry—an eight-page popular narrative-expository bulletin, entirely free from technical details and only incidentally referring to the manufacturing company. DuPont.

Neoprene—a 6 by 9 bulletin, comprising information presented in a semi-technical style under nine clearly separated divisions, a short history of the development of the product being inserted at the middle of the book. DuPont.

DISCUSSION

Modern Mechanical Power Transmission for Industry—a bulletin which discusses in order the planning of drives, the applications and advantages of modern group drives, design principles, and drive components, the illustrations being for the most part entirely subordinate to the text. Power Transmission Council, Inc.

Graphite—a small-size booklet which discusses, without the aid of significant illustrations, the use of graphite. The order is simple—introduction, uses, conclusions. The United States Graphite Company.

Mechanical Feed Water Regulation for Boilers—a 28-page bulletin which discusses the principles of feed water regulation introduced by modern power plant boilers of high output. It is

clearly arranged, the order being as follows: I Why Use a Mechanical Feed Water Regulator?; II How the Water Level Behaves in a Boiler; III The Simple Level Control; IV The Steam-Flow Type Regulator; V The Three-Element Feed Water Regulator; VI Relay Operation of the Feed Valve; VII Differential Pressure Control; VIII Boiler Feed Pump Pressure Control; IX Master Pump Control; X Improvements in Control Valve Design; XI Some Results of Correct Feed Control; XII A Summary of Checking Points. The text is broken by short paragraph divisions and by enumerations of detailed points in outline form. Northern Equipment Company.

Gas-filled Electronic Tubes—an 8-page typewriter-form booklet which discusses control and regulation applications, major classifications, definitions of gas tube ratings, ignitor starting requirements, etc. General Electric.

Roto-Louvre Dryer—a 22-page bulletin descriptive of one piece of apparatus, the order of the contents being (1) illustration plus general statement of advantages, (2) reasons for effectiveness stated under seven main headings in boldface large type, a single paragraph under each heading, (3) uses in three major industries, (4) detailed exposition of process, (5) applications. Link-Belt Company.

INSTRUCTION

Type-C Turbines. Instruction Book 6125 (Rev. 2)—the discussion in typewriter form, preceded by a full index on the back of the title page, is supplemented by detailed drawings. For the discussion, there are four main headings, centered, and marginal subheadings in each division. Westinghouse.

How to Select and Apply Electric Immersion Heaters for Heating Liquids—an 8-page folder, with four main headings, centered, appropriate center or marginal subheading, and accompanying charts and date tables. General Electric.

Grasselli Spraying and Dusting Schedule—a 24-page book of information or instruction, the material being presented very clearly by means of a compact table of contents and of divisions in which boldface headings, tabular statements, and lay-out on the page contribute toward effectiveness. DuPont.

POPULAR

The Loop Course—a 24-page bulletin, addressed to college and university graduates, setting forth, after an introduction by the President, some of the important activities of plants of the Company, the nature of the Loop training course, entrance require-

ments, and concluding with a pertinent section of questions and answers concerning the course. Bethlehem Steel Company.

Public Transit's the Way to Move People—a very informal good-will booklet, in which the illustrations, in part most untechnical, and the jingles are designed to create good feeling in the reader. General Electric.

Thus Spake Haroun-al-Rashid—a somewhat more dignified bulletin from the same company, using an "Arabian Night's Tale" as an introduction to a general story of the accomplishments of this particular company.

Engineering Progress—a 40-page, amply illustrated bulletin addressed primarily to the employees of the Company, in which is told the story of recent contributions of the Company to the world. A table of contents indicates the six main divisions of the subject matter and the subdivisions of each main division, all of these divisions being indicated by center and marginal headings in the text. No special appeal to the reader is attempted. The assumption is that the exposition of facts is in itself of enough interest to the special reader to whom the pamphlet is directed. Westinghouse.

CATALOG

Industrial Control Devices—aside from a general introduction, which presents very compactly necessary information about the design and working of automatic control systems, this bulletin is devoted entirely to outline descriptions with illustrations of the many units involved. Minneapolis-Honeywell Regulator Company.

Industrial Portable Vacuum Cleaners—an 8-page folder presenting outline detailed descriptions of machines and tools. The Spencer Turbine Company.

Condensed Catalog of the Babcock & Wilcox Company and the Babcock & Wilcox Tube Company—a 48-page bulletin presenting for each unit a compact statement in isolated paragraphs and an illustration of design and features.

Luminous-Tube Transformers—a minimum of text accompanying tables and illustrations of various classes of transformers. General Electric.

Westinghouse Equipment for the Pulp and Paper Industry—a combination of a technical-exposition and a catalog bulletin, presenting special features of format, illustrations, introductory general descriptions, and detailed information about particular characteristics, all planned to make a special appeal to one class of manufacturers.

P. I. V. Gear—a catalog, the dullness of this kind of bulletin relieved by ample effective illustrations. Link-Belt Company.

PICTORIAL

For the sake of convenience, the last class of bulletins is labeled "pictorial." As implied by the label, there are a minimum of textual matter and a maximum of illustration.

Taylor Water Cooled Stoker—an 8-page folder, involving one page only of textual matter. The photographic illustrations are particularly striking. American Engineering Company.

Triclad Induction Motor—a pictorial fact book of motor achievement. General Electric.

Conveyors and Elevators for the Boiler Plant—a bulletin, largely pictorial, in which the text appears from page to page as brief statements intended to emphasize the important features of the illustrations, which cover the full page. Link-Belt Company.

Exercises

A Bring to class and discuss the merits and demerits of several bulletins in the light of the discussion in this chapter.

B Make outlines or plans of the layouts of different kinds of bulletins.

C Write brief complete bulletins on material with which you have acquired a first-hand acquaintance through laboratory or shop practice or through visits to manufacturing establishments.

CHAPTER 8

The Development of Specifications

THE DEVELOPMENT of specifications is an important part of the work of many engineers—in private practice, in public office, in consulting and manufacturing engineering firms. For all construction work of any magnitude, specifications about the conditions under which it must be carried on are essential. The purpose of this section is to present material which may assist the young engineer in presenting a set of specifications with the necessary orderliness and clarity. It is assumed that the engineer will turn to other sources of instruction in the engineering and legal problems involved and that he will also consult printed specimens of specifications which are abundantly available in engineering libraries. The contents of this section should of course be supplemented by reference to Chapters 1, 2, and 3.

Content of a Set of Specifications

Five documents are necessary to make a complete set of specifications:

1 Advertisement
2 Specifications proper
3 Proposal
4 Contract
5 Bond

Advertisement. The advertisement, also known as the proposal advertisement, information for bidders, or notice to bidders, is an invitation to all interested parties to submit estimates upon a proposed construction job or other transaction. It briefly describes the work to be done and specifies the manner in which bids are to be submitted. A typical advertisement contains

1 Title and date
2 Name of owner

3 Brief description of the work
4 Types of bids desired, name of person receiving bids, place and time of receiving bids, time of opening bids
5 Security required with bid
6 Security required for performance of contract, terms of payment, and other financial arrangements
7 Conditions attached to examination of plans and specifications
8 Reservation of right of rejection
9 Signature of officer responsible for receiving bids or letting contract

See the example on pages 431-432.

Specifications proper. Specifications proper are so various in subject matter that it is not possible to offer here anything more than a general idea of the nature of the items which are customarily taken into consideration.[1]

What major matters are included in a typical example of specifications proper? The nature of the work or product is described, and the conduct of the work and the conditions of its completion are defined. The respective responsibilities and liabilities of contractor and of owner are stated and agreed upon. Provision is made for arbitration of disputes. The financial conditions of the contract are set forth, as they affect both parties. A form of bid is supplied to be executed by the bidder. In short, the specifications proper define the undertakings and protect the rights of both parties to the proposed contract.

Although no "typical" make-up can be given, the following outline attempts a logical analysis of the more common items in the specifications proper. The principal headings correspond roughly with general clauses, the subordinate headings with specific clauses; but this outline is no more than suggestive and must be modified by the particular conditions governing the writing of each section of the specifications proper.

I Contractor's undertaking

A Nature of the work
1 Definition of terms used
2 Designing rules
3 Rules for classification and estimating

[1] For a more detailed treatment of the subject, students should consult special texts on contracts and specifications.

- 4 Extent of the work
- 5 Labor and materials to be furnished
- 6 Accompanying and contemplated drawings

B Conduct of the work
- 1 Method of construction
- 2 Quality of materials
- 3 Quality of workmanship
- 4 Dimensions and proportions
- 5 Capacity or required performance

C Completion of the work
- 1 Condition of finished work
- 2 Inspection
- 3 Acceptance tests
- 4 Cleaning up

D Liability
- 1 Bond
- 2 Penalties for delays
- 3 Guarantees
- 4 Court actions

II Owner's undertaking
- A Labor and materials to be furnished
- B Risks assumed
- C Amount and terms of payment

III Mutual undertakings
- A Arbitration of disputes
- B Costs
  - 1 Extra work
  - 2 Alterations
  - 3 Allowances
- C Contract
  - 1 Duration of contract
  - 2 Assignment of contract
  - 3 Liens

Study the two following examples. See also pages 432 to 439.

1

BRIEF MANUFACTURER'S SPECIFICATIONS

FOR STRAIGHTLINE SLUDGE COLLECTORS[2]

Under this item the contractor shall furnish complete sludge collector mechanisms for settling tanks as described below and shown on the drawings.

[2] Specifications supplied by the Link-Belt Company

The manufacturer furnishing these collectors shall be experienced in the design and construction of such machines for this purpose and shall have furnished equipment for a sewage treatment plant which has been successful in operation for a period of not less than two (2) years.

DRIVING MACHINERY

The motor shall be of ample strength to drive the collector mechanism. It shall be of the totally-enclosed type suitable for outdoor operation and shall be designed for ___ volts ___ phase ___ cycles current.

The following electrical equipment shall be furnished:

One (1) 3-pole double-throw oil immersed reversing switch for the disengagement of the clutches.

One (1) 3-pole magnetic starter switch providing overload and undervoltage protection—push-button operated—all in one case suitable for outdoor operation.

The main fused starting switch to be furnished by the general contractor shall be located on the main panel board in the building.

FOR SINGLE COLLECTOR

The reducer for a single collector shall be of the motorized worm gear type.

FOR TWO OR MORE COLLECTOR INSTALLATIONS

The reducer shall be of the motorized worm or helical gear reducer type. The reducer housing shall be bolted to the floor and the motor bolted to the housing. All reducers shall be equipped with antifriction bearings.

Each driving sprocket shall be provided with a breaking pin for overload protection.

Chain and gear guards shall be of No. 14 steel galvanized. Foundation bolts and nuts shall be galvanized.

CHAIN

Each machine shall be made up of a double strand of chain to which will be attached at intervals of approximately 10 feet flights about 6 in. deep.

The links of the collector chain shall be made from Processed malleable iron which shall have an average ultimate strength of 70,000 lb per square inch in a standard test bar and the Brinell

hardness of not less than 170 throughout the entire section of the link. The elongation shall not be less than 8% and the combined carbon from .20 to .40. Pins shall be of copper bearing steel. Sprockets shall have Chilled-Rims and be made to fit the chain.

FLIGHTS

The flights shall be made from redwood. They shall be equipped with steel wearing shoes to slide on the steel rails set into the floor of the tank and another set of shoes to slide on the angles of the return track. Two flights of each collector shall be attached to the chain by Pivoted Cast Steel Attachments to permit sweeping out of the corners of the tank and removal of all the sludge from the bottom of the tank under the lower turn shafts.

BEARINGS

All submerged bearings shall be of the self-aligning type designed to prevent an accumulation of settled solids on any part of them. They shall be water lubricated.

CLUTCHES

Each collector shall be provided with a jaw clutch so that one or all may be operated at one time (NOTE: No clutches used on single tank installations).

ANGLE TRACKS

Angle tracks for the return run with supports to the tank wall shall be furnished by collector manufacturer.

GENERAL

All structural steel shall conform to "Standard Specifications for Structural Steel for Bridges" of the A.S.T.M. All iron castings shall be of tough, close grained gray iron, free from blowholes, flaws,- or excessive shrinkage. They shall all conform to the "Standard Specifications for Gray Iron Castings" of the A.S.T.M.

All parts of the mechanism shall be amply proportioned for all stresses which may occur during operation and for any additional stresses which may occur during fabrication and erection.

Duplicate parts shall be interchangeable.

All material furnished under this item shall be guaranteed free from defects in workmanship, design, or material. The contractor shall furnish, without cost to the City, any part or parts of any equipment defective or showing undue wear within one (1) year after the equipment has been placed in permanent operation.

TO BE FURNISHED BY GENERAL CONTRACTOR

Two 25-lb or heavier rails shall be placed in the bottom of each tank. They shall be straight and true and bolted together. The elevation of the top of the rails shall be the same as the bottom of the tank. The surface of the bottom of the tank shall consist of concrete with small aggregate. After this concrete is placed it shall be screeded flush with the top of the rails and floated. The sides of the tanks shall be true and parallel; they shall not deviate more than 1 in. from a straight line through the center of the tank.

2

MANUFACTURER'S SPECIFICATIONS

SPECIFICATION

for

2500 KVA O.I.S.C. TRANSFORMERS

for

————— Power Company

1 *SCOPE OF WORK*

This specification covers the design, manufacture, and delivery to substation to be later specified by the Power Company of:

2500 kva Transformers

2 *GENERAL*

Where not otherwise specified the transformers shall be in accordance with the latest standards of the American Institute of Electrical Engineers.

3 *TYPE*

The transformers shall be outdoor, oil-immersed, self-cooled, with provision for future addition of forced-air-cooling equipment for obtaining increased rating.

4 *RATING*

Continuous Rating Kva	Volts High Tension	Volts Low Tension	Cycles Per Second	Phase
2500	33,000	2483/4300Y	60	Single

The low-voltage windings of the transformers shall be provided with four (4) rated kva taps giving the following no-load voltages: 2671; 2607; 2547; and 2425 volts.

The transformers shall be provided with taps on the low-voltage side to obtain the equivalent of two (2) 5% (of 33,000 volts) reduced voltage rated kva high-voltage taps.

The transformers shall be so designed that, by the addition of equipment for applying forced-air-cooling to the radiators or tubes without changing the existing equipment, a continuous rating as specified in the Contractor's proposal shall be secured. Under these conditions, the bushings, no-load tap changers, etc, shall have the same increased capacity with an ample factor of safety.

5 *TEMPERATURE RISE*

The observable temperature rise of the transformers shall not exceed 55° C at an ambient temperature of 40° C when operating continuously at any rating specified, with connections giving the greatest heating, with rated frequency, and with impressed voltage sufficient to maintain rated secondary voltage.

6 *SERVICE*

The transformers will be used for general primary distribution from suburban substations.

The transformers shall also be designed for operation between a nominal 33,000-volt, 3-phase, 60-cycle system and a nominal 4000-volt, 3-phase, 60-cycle system when used in a bank of three transformers with high-voltage windings connected Delta and low-voltage windings connected Wye.

The transformers may be operated on systems where the neutrals on either high- or low-voltage sides may be solidly grounded, grounded through a resistor, or ungrounded.

The transformers when used in a bank of three, with high-voltage windings connected Delta and low-voltage windings connected Wye, shall operate successfully in parallel with General Electric Company 5000-kva three-phase, oil-immersed, self-cooled transformers, serial numbers on all corresponding tap positions at any load and power factor for which the transformers are designed. Parallel operation shall be such that load will divide in proportion to the forced air-cooled rating of the transformers covered by this specification and the 7500 kva forced-air-cooled rating of the General Electric Company transformers. Such parallel oper-

ation shall be in accordance with the American Standards Association proposed standards for transformers.

7 *IMPULSE STRENGTH*

In view of the severe lightning conditions at the locations where these transformers will be installed, the Contractor shall give special attention to the design of the transformers to enable them to withstand lightning voltages.

The transformers shall be designed for insulation levels of 34.5 and 5 kv in accordance with the American Standards Association proposed standards for transformers.

8 *TERMINALS*

Spacing between all terminals shall be as large as practicable.

All line terminals and the middle tap terminal of the high-voltage windings shall be brought out through bushings.

The line bushings of the high-voltage windings shall be arranged so that multi-ratio bushing-type current transformers may be readily installed at a future date.

9 *CONSTRUCTION FEATURES*

The transformers shall be provided with automatic inert gas protection in the form of a cushion of nitrogen gas above the oil.

The Contractor shall furnish the nitrogen gas with the transformers initially and shall furnish such re-charges as may be necessary during the period of adjustment and preliminary operation prior to acceptance of the transformers by the Power Company.

The blow-down and test valves shall be so arranged that a Hays Improved Gas Analyzer or equivalent equipment can be conveniently attached. A gas analyzer shall be supplied with the transformers.

The transformers shall be equipped with capillary-tube dial-type thermometers with 250-volt alarm contacts to indicate transformer hot oil temperatures. The scale range of these thermometers must be such that it will enable the operator to determine the oil temperature over the full operating range of the transformers as described above.

The transformers shall be provided with readily accessible lock-shield drain valves of sufficient size to permit rapid drainage of all transformer oil. The transformers shall be provided with 1½-in. filter press valves of the lockshield type.

The transformers shall operate successfully when filled with

the oil supplied by the Contractor, with G.E. 10-C oil, with Wemco "C" oil, or with any mixture of these oils.

Any oil gauges which are used to indicate the height of oil in the tank shall be of the magnetic type. In addition to the usual calibration, the scale of the oil gauge on the main tank shall be marked to indicate the point at which the oil level is even with the top of the top radiator connection. This point on the scale should be marked "full rad."

All radiator connections, if the transformers have separate radiators, shall be provided with suitable valves between the radiators and the main transformer tanks which will permit the removal of any radiator without draining the oil from the transformer tanks, and each radiator shall be provided with means for draining the oil before the radiator is removed from the transformer tank.

Suitable means shall be provided so that the transformers with oil can be readily lifted and also so that they can be jacked from the foundations.

The transformers shall be furnished with structural type bases with broad flanged wheels for standard gauge and shall be mounted so that movement is in a direction of motion perpendicular to a plane through the high-voltage bushings. Means shall be provided for the lubrication of wheel bearings.

Tap changers for operation when the transformers are disconnected shall be provided on the low-voltage windings operated by hand devices external to the tanks, with facilities for locking.

Connections for changing taps on the high-voltage windings shall be made on terminal boards provided for the purpose.

Where special tools not readily purchased on the market are required for the installation and maintenance of the equipment, one set shall be furnished by the Contractor.

10 *TESTS*

A complete factory test, including full-load heat run, shall be made on at least one of the transformers and three certified copies of the reports covering these tests as well as partial tests on the remainder of the transformers shall be furnished the Power Company.

Each transformer shall have resistance tests made on both the high- and low-voltage windings. Resistance and impedance measurements and voltage ratio test shall be made on the full windings of each transformer and on the various taps of at least one transformer.

The transformer windings shall be tested at and shall be capable of withstanding for one minute the following 60-cycle test voltages at the factory before the transformers are shipped, and at 75% of these values in the Power Company Substation.

High-voltage winding to low-voltage winding and ground —70 kv.

Low-voltage winding to high-voltage winding and ground —19 kv.

The transformer bushings shall be tested at and shall be capable of withstanding for one minute the 60-cycle dry test values stated in the Contractor's proposal.

11 *PERFORMANCE*

The Contractor shall guarantee among other things that the performance of the transformers shall be at least as good as follows, the values to be as given in his proposal:

(1) Efficiencies at 100% P.F. at 75° C. for 150%, 125%, 100%, 75%, and 50% load.

(2) Losses:
No load losses at 100% and 110% voltage.
Total losses at full load by wattmeter at 75° C.

(3) Impedance:
The impedances shall be guaranteed to be within 7½% of the specified values.

(4) Regulation:
Regulation at 100% P.F.
Regulation at 80% P.F.

(5) Exciting current at 100% and 110% voltage.

(6) Continuous permissible loads at ambient temperatures below 40° C. for both self-cooled and forced-air cooled operation.

(7) Ten-second wet high-potential bushing tests.

(8) Dry and wet bushing 60-cycle flashover voltages.

(9) Impulse strength of windings (based on 1½ by 40 micro-second wave).

(10) Impulse flashover of bushings (based on 1½ by 40 micro-second wave).

Proposal. The proposal, also called the bid or estimate, is a brief document in response to the advertisement. Ordinarily it merely names a price. In special cases, the bid is accompanied by alternative bids, or is qualified by detailed conditions.

A typical proposal contains

1 Identity of the work referred to
2 Declaration of bidder regarding examination of proposed work
3 Price or prices
4 Conditions attached to bid
5 Certified check
6 Full names and addresses of bidders

Study the example on pages 439-441.

Contract. The contract is the formal agreement between the owner or purchaser and the contractor. It is ordinarily a brief instrument and includes

1 Title and date
2 Statement of the parties to the contract
3 Extent of work as shown in plans and specifications proper
4 Agreements
5 Signatures

Contracts follow the approved legal form for such documents.

Bond. The bond is a document which pledges a sum of money as security against loss or damage or unsatisfactory performance. It also follows the approved legal form.

Composition of Specifications

The writing of specifications makes the most exacting demands upon the writing ability of the engineer; not that it calls for skills different from those employed in other types of technical writing, but that it calls for those skills in their highest degree. A set of specifications is in effect an elaborate set of directions. If these directions are to be carried out to the satisfaction of all parties to the contract, they must be composed with a precision beyond question, a clarity above reproach.

Purpose. The general purpose of a complete set of specifications is to convey, from owner to contractor, directions for the

performance of a piece of work, these directions being expressed in such terms that the work shall be done exactly as desired and that no work shall be done which is not desired. Duplicate copies are deposited with both contractor and owner.

Planning. In the carrying out of this purpose, the writer of specifications must follow the principles and practices which belong to all other kinds of technical writing. Adequate planning is, as usual, the first essential. Complete material must be assembled and arranged. A knowledge of existing specifications for similar work and of the requirements of the job in hand is fundamental. Clauses of existing specifications must be adapted to fit the particular problem. On separate cards or sheets of paper the writer should note the main divisions and subdivisions of his material. He should take care to include every essential detail and to exclude nonessentials, and also to put under the appropriate division everything that belongs to that part of the work. The use of cards for the separate divisions of the work helps in the logical planning of specifications. It enables the writer to group related items under appropriate headings, to insert afterthoughts, and to check up readily on the completed plan. A carefully constructed outline eliminates repetitions, contradictions, omissions, and the possibility of illogical arrangement. The outline being completed, there follows the task of expanding the topics into the clauses of the finished specifications.

Style. The writing of specifications should be ruled by the thought that the several clauses are directions, not suggestions. They should be as curt and definite as the orders of a military officer to his subordinates. In the word "specifications" itself is plain indication that we are dealing with *specific* matters. *Specify* exactly what is to be done. A set of specifications is no place, to be sure, for the refinements of a literary style; but it is the place, above all, where a plain, correct style matters most. Do not hesitate to repeat words or phrases as many times as necessary rather than court the danger of being misunderstood. The most monotonous repetition is preferable to ambiguity in a set of specifications.[3]

Use a separate paragraph for each independent item, or

[3] See Rolf T. Retz, "The Language of Specifications," *The Military Engineer*, Vol. 35, No. 209 (March, 1943), pp. 130-131.

"clause." Specifications present statements of fact, not discussions of ideas. Hence the paragraphs are, as a rule, paragraphs of isolated statement.

Sentences should be short, simple, grammatically complete. Clearness is menaced by omission of the verb or substitution of an infinitive for the verb, except in items in an enumeration which are not intended as sentences. Build each sentence about a single idea. If more than one idea must be handled in the same sentence, make the relation between the parts of the sentence unmistakable. Give particular care to the punctuation of sentences. A misplaced comma may easly cause misunderstanding and has even been known to lead to lawsuits. Allow no chance for the contractor to misinterpret the intent of a specification through errors in grammar or ambiguity.

The language of specifications must be precise and unequivocal. Every word must mean to every reader exactly what the writer intends it to mean, and nothing else. That is to say, there can be no ambiguity. Words must be used in the sense in which they are understood by the parties concerned, and no word should be employed which may, under the conditions, be susceptible of more than one interpretation. Beware especially of vague and meaningless terms, such as "about," "reasonably," "approximately," "should be," "suitable material," "ample capacity," "workmanlike manner," "good and sufficient," "ordinary," "customary," and so forth. Do not omit words with the expectation that they will be understood. Take no "understandings" for granted. "Of course, the law will interpret a contract or a specification in accordance with what the court decides is its spirit, but an engineer should not rely upon this to guard against omission. If the specifications are properly prepared, there should be no occasion for appealing to the courts to decide what is or is not the spirit intended."[4]

Mechanical aids. A set of specifications is intended first for study, then for constant reference until the completion of the job. Mechanical aids, similar to those employed in reports and in bulletins, are therefore desirable adjuncts, since they make both for ready understanding and for convenient reference. Since they have been explained in earlier chapters, they will be merely listed here.

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[4] Waddell and Wait, *Specifications and Contracts*, p. 6

1 For specifications of considerable length furnish a table of contents and an index.

2 Number the paragraphs consecutively throughout.

3 Indicate the relative importance of parts, if desired, by a system of letters and numbers similar to that used in outlining:

I Subtitle
    A Main division
        1 Section
            (a) Subdivision of section

4 Use center headings for main divisions of the material and marginal headings for important sections.

SET OF SPECIFICATIONS

The following specimen represents a complete set of specifications except for the contract and the bond, the two legal documents.

SPECIFICATIONS[5]

for

DEEP-WELL TURBINE PUMPS

for the

WATER WORKS DEPARTMENT

CITY OF LANSING

MICHIGAN

BOARD OF WATER & ELECTRIC LIGHT COMMISSIONERS
LANSING, MICHIGAN

May 12, 19—

[ADVERTISEMENT]

NOTICE TO BIDDERS

The Board of Water & Electric Light Commissioners will receive sealed proposals for five (5) Deep-Well Turbine Pumps for the

[5] Specifications supplied by Mr. Claude R. Erickson

Water Works Department, Lansing, Mich. Bids will be received up to 1:30 p.m., Eastern Standard Time, Friday, May 23, 19—, at the Office of the Board of Water & Electric Light Commissioners, 116 W. Ottawa Street, Lansing, Michigan.

Specifications and bidding forms may be obtained from the Board of Water & Electric Light Commissioners, Lansing, Michigan.

Bids must be accompanied by certified check in an amount not less than ten (10) per cent of the amount of the bid.

The right is reserved to reject any or all bids.

BOARD OF WATER & ELECTRIC LIGHT COMMISSIONERS
W. B. Kirby, Secretary.

[SPECIFICATIONS PROPER]

[There follows here *The General Conditions of the Contract for the Construction of Buildings*, the standard form of the American Institute of Architects, a printed document of 10 pages.]

GENERAL CLAUSES

DEFINITION OF TERMS USED The general conditions of the contract are in accordance with the standard form of the American Institute of Architects, which will apply in this contract as stated hereinafter; and where the name Architect is used in the printed form, it refers to Otto E. Eckert, Superintendent, Board of Water & Electric Light Commissioners, Lansing, Michigan.

The terms used in the specifications are defined as follows:

"Owner" shall mean the City of Lansing, represented by the Board of Water & Electric Light Commissioners.

"Engineer" shall mean Otto E. Eckert, Superintendent of the Board of Water & Electric Light Commissioners, Lansing, Michigan.

"Contractor" shall mean a person or persons who have contracted for the completion of the work as herein specified or shown on the drawings.

COURT ACTIONS The Contractor will indemnify and save harmless the Owner against all liability under or pursuant to any Workmen's Compensation Act or any act of similar purport now in force or hereafter enacted, and for damage arising out of, or caused by, any accident to persons or property happening by reason of the acts or omissions of the Con-

tractor or the employees or agents of the Contractor in the performance of the work comprehended in this agreement, including all costs, charges, and expenses of whatsoever kind that the Owner may be put to by reason of any claim being made for such damage or compensation, or arising out of any litigation in regard thereto, and in event that any claim for compensation or damage is made or any action commenced or proceedings taken against the Owner by or on behalf of any person or persons employed directly or indirectly by the Contractor, or under control of the Contractor, the Owner shall have the right to retain out of any payment then due, or thereafter to become due, an amount sufficient completely to indemnify it against all such claims, actions, or proceedings. Should such amount be in excess of the amount due, or to grow due, to the Contractor under this agreement, then the Contractor agrees to pay the Owner the amount of such excess.

All insurance policies shall be issued by the Companies authorized to do business under the laws of the State of Michigan.

PROPOSALS Proposals shall be made in duplicate as per accompanying blank forms, enclosed in sealed envelopes marked with title of specifications, and addressed to W. B. Kirby, Secretary of the Board of Water & Electric Light Commissioners, Lansing, Michigan, stating in writing and figures (without interlineation or erasure) the sum of money for which the bidders propose to supply the materials and perform the work required by this specification, together with the data relating to materials, appliances, apparatus, etc, proposed to be used by the bidder. Proposal forms not properly filled out will be rejected.

Proposals must be signed with the full name and address of the bidder; if a copartnership, the copartnership name of a member of the firm, with the names and addresses in full of each member; and if a corporation, by an officer in the corporate name, the corporate seal attached to such signature. No telegraphic proposals or telegraphic modifications of proposals will be considered. Proposals received after the time advertised for the opening will be returned unopened. If proposal is sent by registered mail, allowance should be made by the bidder for additional time required for such transmission.

CERTIFIED CHECK Each bidder must submit with his proposal a certified check or bid bond in an amount of ten (10) per cent of the proposal drawn to the order of the Board of Water & Electric Light Commissioners, and the proceeds of such check shall become the property of the Board of Water & Electric Light Commissioners, if for any reason whatever the bidder, after the opening of the bids, withdraws from the com-

petition or refuses to execute the contract and bond required in the event of said contract being awarded to him. The checks submitted by the unsuccessful bidders will be returned after the approval of the contract and bond executed by the successful bidder.

BOND The successful bidder will be required to furnish and execute a Surety Bond in the full amount of the contract price named for the work.

TERMS OF PAYMENT Payments will be made as follows:
Payment will be made by the purchaser on the pumps after satisfactory evidence by test or otherwise that the equipment meets the guaranteed conditions set forth in the Contractor's proposal. The test shall be made after the pumps have operated for 30 days and within 60 days after equipment is installed and ready for operation. Should the Contractor fail to meet the guaranteed conditions set forth in his proposal, no payments shall become due and payable.

The Owner shall reserve the right to contract for any number of pumping units up to five at the unit prices set forth in bidder's proposal, or contract for five at the prices for five pumping units set forth in the bidder's proposal.

ALIEN LABOR The Contractor's attention is called to Michigan Laws pertaining to Alien Labor on public work, and to any other laws governing this class of work.

EXAMINATION OF PREMISES It will be assumed that those tendering proposals shall have made all necessary examination of the premises and shall have satisfied themselves as to the condition under which the contract is to be carried out should they be awarded it. No allowance will be subsequently made by the Owner due to any error or omission of the bidder.

COMPETENT MECHANICS All work under these specifications shall be done by skillful and competent mechanics. So far as practicable, citizens of Lansing shall be employed in executing this contract.

FACILITIES One of these pumps will be located in the Townsend St. Station, one in the Seymour St. Station, and three in the Northwest Well Field. In the Seymour St. Station and Townsend St. Station there is an overhead crane suitable for setting the pump. In the Northwest Well Field a portable derrick will be furnished by the Owner.

The contractors shall assume all responsibility for care and protection of the pumps after unloading.

GUARANTEE The complete units shall be guaranteed for one year from date of acceptance, and the maker agrees to furnish and replace, free of charge, all parts found defective because of poor design, material, or workmanship.

Should the pumping unit fail to meet the several guarantees, then the Contractor shall have the right to make such changes in the equipment as will enable the City to secure such guarantee. All charges for such changes shall be borne by the Contractor.

In the event that the efficiency, capacity, or duty of the unit as guaranteed is not fully shown within a reasonable time by the Contractor, the City may reject all or any part of the equipment.

Should the City elect to reject equipment on account of failure of the Contractor to meet guarantees, the Contractor shall remove the pump or pumps from the wells and accept it for credit at the well site for the full contract price.

SPECIFIC CLAUSES

NATURE OF THE WORK The specifications are intended to cover the furnishing, delivery, and erection of Deep-Well Turbine Pumps in the Seymour St. Station, Townsend St. Station, and Northwest Well Field, for the Water Works, Lansing, Michigan. Foundations, piping, electrical work will be under another contract, but such drawings necessary to show the requirements of such foundations and connections for piping, etc, shall be furnished by the Contractor.

All motors are to be induction high-reactance type wound for 440 volts, 3-phase, 60 cycles, 40° C, equipped with magnetic switch G. E. Co. C. R. 7006-D7 3-pole with G. E. Company C. R. 2824-TC-131C temperature overload relay. Contractor is to supply push-button station G. E. Co. C. R. 2940-BS-12 KW, and a reverse phase relay PI-3, or approved equal.

The water to be handled by the pump may have the following approximate analysis:

Total solids	283.0 ppm
Solids, dissolved	283.0
$Si\ O_2$ (silica)	21.6
$Fe_2\ O_3$	1.5
Ca	62.0
Mg	23.5
Na plus K	5.5
Cl	5.0
SO_4	17.5
HCO_3 (bicarbonate)	320.0
Temperature of water	51° F

The pumping units are to be so designed that should the pumping water level recede to a greater depth than specified 30 feet, an additional pump column may be installed giving greater submergence.

Pumps having oil-lubricated bearings shall be equipped with automatic lubricators for feeding oil and bearings.

The actual capacity of any head shall not exceed five (5) per cent of that guaranteed.

REQUIREMENTS

Unit No.	1	2	3	4	5
Location	Seymour St. Station	Townsend St. Station	Well No. 1	Well No. 2	Well No. 3
Size of well, inches	14 O.D.	14 O.D.	12	12	12
Depth of well, feet	396	425	505	425	418
Length of casing, feet	48.67	40	30.5	73	63
Specific capacity of well, gpm per ft drawdown	5.0	3.4	5.5	5.5	5.5
Elev. top of casing, feet	818.5	829.33	818.21	843.96	833.15
Temperature of water, deg F	51	51	51	51	51
Static water level below top of casing, feet	40	20	45	70	60
Pumping level, below top of casing, feet	120	140	125	150	140
Top of pump bowls below grade, feet	170	170	170	170	170
Head above grade, feet	195	175	190	165	175
Total pumping head, feet	315	315	315	315	315
Capacity of unit, gpm	400	400	400	400	400

Note: All pumps shall be designed to deliver 400 gpm against a total head of 315 feet.

MATERIALS Column discharge pipe shall be of Toncan metal, standard weight, in 10-foot sections.

Suction pipe shall be at least 20 feet long of solid pipe 8-in. diameter, of Toncan metal.

Strainer shall be of Bronze or Toncan metal and have a free area of not less than 200 sq in.

Cover pipe (if used) shall be extra heavy Toncan metal, lap welded.

Column shafting shall be of A-1 grade Cumberland twined and ground steel; if no cover pipe is used, shafting shall be stainless steel or Tobin bronze.

Pump impeller shafting shall be turned and ground stainless steel. It shall be provided with stainless steel keys for the impellers.

Air line shall be ¼-in. diameter of Toncan metal, 190 feet long. This line shall be anchored to pump with non-corrosive wire or straps. The top of the air line shall be equipped with altitude gage and connection for air pump.

Pump impellers shall be manganese bronze, accurately and smoothly finished, and dynamically balanced.

The discharge flange on the pump shall be of standard size and drilling for an 8-in. standard flange; outside diameter 13½ in., bolt circle 11¾ in., ⅞-in. bolt holes.

FURNISHED BY OWNER

The Owner will furnish:

1 Common labor for installing pump
2 Suitable foundations for pumps
3 Derrick or crane for installing pump
4 All electric wiring necessary to make connections to motor
5 All water piping from discharge flange
6 Necessary labor, materials, piping, instruments, etc, necessary to conduct one official test on each pumping unit. Expense for any other tests shall be borne by Contractor.

FURNISHED BY CONTRACTOR

The Contractor shall furnish:

1 Deep-Well pumps herein specified complete and ready for operation
2 Services of erection engineer
3 Drawings showing dimensions of unit
4 Test engineer to observe official test for acceptance of pumping unit

REFERENCES

The bidder shall submit with his bid evidence in support of his ability to furnish machinery of efficiency equal to the bidder's guarantee, which evidence shall include tabular or diagrammatic summaries of certified tests upon similar machinery manufactured by him under operating conditions of capacity and head as near as possible to those herein required.

PATENTED EQUIPMENT The Contractor shall defend and hold the City harmless from any action that may be brought against it through the use of any patented equipment furnished by the Contractor in connection with this work.

COMPLETION Each bidder must state in his bid the least time that he will require for the fulfillment of the conditions of this contract.

METHOD OF TESTING These pumps shall be tested for head capacity, efficiency (pump), hp to pump, overall efficiency (wire to water), and duty (kwhr per million ft-lb of work done).

The water will be measured by a 90° V-notch weir, using formula $Q = 2.52\ H^{2.47} \times 7.48 =$ gallons per second.

The head against which the unit is pumping will be determined with a tested gage placed at a distance of 1 ft from the flange on the discharge to the pump. This head shall not under any condition be taken before the water leaves the discharge opening of the pump.

See drawing of weir box for dimensions.

SELECTION OF PUMP Price, guaranteed economy, and mechanical construction will be taken into consideration in awarding contract.

The following data may be used in calculating comparative economy: Pumping unit operating 5000 hours per year, energy at 1.0c per kwhr. Demand at $20 per year per input horsepower, 20% fixed charges.

Should it become necessary for the Contractor to replace any portion of the pumping equipment or make such changes requiring a shutdown of the pumping unit in order to make guarantees, the shutdown shall be made at a time designated by the Owner.

Should the pumping units after installation fail to make guarantees, the Owner reserves the right to use the pumping unit until Contractor makes the necessary changes, without any obligation to the Contractor.

Contractor shall submit performance curves showing the characteristics of unit from 200 to 600 gpm. Curves shall include data for head capacity, pump efficiency, overall efficiency, and kilowatts to motor.

These specifications must be returned with proposal.

ADDENDA:

Pump bowls shall be made of phosphorus bronze—88% copper, 10% phosphorus tin, 2% lead; with impurities limited as described in specifications of the U. S. Navy covering this alloy.

Contractor shall submit with proposal statement showing the constituents of the bronze to be used in both the impellers and the bowls.

[A blueprint and a map, which follow here in the complete specimen, are omitted.]

[PROPOSAL]

PROPOSAL FORM TO BE COPIED BY BIDDERS

. . . . 19. . .

Name of bidder. . . . .

The undersigned proposes and agrees to contract with the Board of Water & Electric Light Commissioners, Lansing, Michigan, to furnish all the labor, materials, and equipment, perform all the work called for by the specifications prepared by the Board, entitled "Specifications for Deep-Well Turbine Pumps," and agrees to accept as payment therefor:

$. . . . . .For one unit installed complete as per specifications
$. . . . . .For two units installed complete as per specifications
$. . . . . .For three units installed complete as per specifications
$. . . . . .For five units installed complete as per specifications
Number of days to complete contract (excluding Sundays and holidays) . . . .

The undersigned further proposes and agrees that the execution of his work and the character and performance of the completed work will conform to the following:

1 Pump size
2 Number of stages
3 Rpm of motor
4 Motor hp rating
5 Make of motor
6 Type and manufacturer of starting equipment
7 Size and weight per ft of column pipe
8 Material in pump column
9 Diameter of cover pipe
10 Material in cover pipe
11 Diameter of shafting and material
12 Commercial or turned and ground shafting
13 Diameter of pump shaft
14 Material in pump shaft
15 Materials in impellers
16 Width and diameter of impellers (outside)

17 Length of bottom bearing
18 Length of intermediate bearings, in pump
19 Kind of intermediate bearings, in pump
20 Pump bowl bearings (kind)
21 Material in pump bowls and thickness of metal
22 Overall outside diameter of pump bowls
23 Overall diameter of flanges or couplings on pump column
24 Method of making connections of pump column pipe (couplings, flanges, or lugs)
25 Method of lubricating bottom bearing in pump
26 Method of water seal for shaft column
27 Method of pump lubrication, description of system
28 Capacity of automatic oil lubricator, in quarts
29 Size of suction pipe
30 Length of column drop pipe below pump bowls
31 Are spreaders used in pump? (How many?)
32 Method of providing for thrust and weight of pump
33 Total thrust weight on bearing
34 Rating and manufacturer of thrust bearing
35 Method of protection against reverse operation of pump
36 Sq in. free area in strainer and type of strainer
37 Replacement cost of shaft bearings, each
38 Replacement cost of pump stages, each
39 Replacement cost of pump bearings, each
40 Replacement cost of column pipe, per foot
41 Replacement cost of shafting, per foot
42 Furnish drawing of bottom bearing (full size scale)
43 Furnish drawing showing section of one complete stage (full size scale)
44 Furnish drawing showing intermediate bearing (full size)
45 Weight of one unit complete

Motor & starter	..........lb
Pump	..........lb
Column, shafting, suction, etc.	..........lb
Total weight (net)	..........lb

46 Delivery date
47 Pump efficiency at 350, 400, and 450 gpm. Efficiency to include all friction loss through pump columns and discharge pipe (including friction loss due to 90° bend and flange at discharge).

Pump efficiency =

$$\frac{\text{gpm} \times 8.34 \times \text{Total Head}}{33{,}000 \times \text{kw input} \times 1.34 \times \text{Motor Efficiency}}$$

48 Overall efficiency of pumping units at 350, 400, and 450 gpm efficiency to include all losses in pump, and column.

Overall efficiency =
$$\frac{\text{gpm} \times 8.34 \times \text{Total Head}}{33{,}000 \times \text{kw input} \times 1.34}$$

49 Total head in feet at above ratings, 350, 400, and 450 gpm
50 Kw input to motor at 350, 400, and 450 gpm
51 Motor efficiency and power factor at ¾, full, and 1¼ rating
52 Kwhr per 1,000,000 gallons at 350, 400, and 450 gpm
53 Foot-pounds of work done per kwhr at 350, 400, and 450 gpm

ft lb/kwhr =
$$\frac{\text{gpm} \times 60 \times 8.34 \times \text{Total Head}}{\text{kwhr}}$$

No oral or written agreement or understanding considered or entered into prior to the signing of contract shall be binding after the signing of contract unless incorporated in the contract.

If this proposal shall be accepted by the Board of Water & Electric Light Commissioners and the undersigned shall fail to contract as aforesaid and to furnish the required bonds within ten days, not including Sundays, from date of serving written notice from the Owner that the contract is ready for signature, then the undersigned shall be considered to have abandoned the contract, and the certified check accompanying this proposal for the sum required by the Notice to Bidders shall become the property of the Board of Water & Electric Light Commissioners, Lansing, Michigan. If the undersigned enters into the contract in accordance with this proposal, or if his proposal is rejected, then the accompanying check shall be returned to the undersigned.

Signed and Sealed this............day of............19...

....
Authorized signature of bidder

....
Business address

Specifications for Patents

Specifications—with claims—are of primary importance in the application for a patent. They are accompanied, in a complete application, by the petition, oath, and filing fee. Practice in the composition of the specification is valuable for every engineering student, inasmuch as the fundamental requirements of good technical writing—simplicity, clearness, conciseness,

and completeness—receive special stress in this part of the complete application for a patent. A complete specification embodies the following:[6]

1 Statement of the art, class, or field to which the invention relates
2 Statement of object or objects:
   (a) A brief statement of prior art
   (b) Disadvantages or defects of prior art
   (c) What it is proposed to accomplish as respects the prior art
3 Inventive idea or generic statement of the novel feature or features of the invention
4 Detailed description of invention:
   (a) If a composition, describe ingredients and how they co-act or their functional relations, if possible, giving typical examples stating proportions and how they are compounded.
   (b) If a process, give detailed steps in proper sequence and functions, if possible, with typical examples giving critical operating conditions, materials used, or apparatus used.
   (c) If an apparatus is involved either alone or in connection with a process, give—
      i Brief description of each figure of the drawing, stating whether it is a cross-section, elevation, plan, etc
      ii Description of construction, i.e., elements or parts, significant features, and co-action or inter-relations of the parts or elements
      iii Description of operation
5 Summary of what is accomplished by invention
6 Advantages of invention
7 Claims

From *Rules of Practice* in the United States Patent Office, pp. 9 and 10, are taken the following additional directions for the preparation of the Specification.

"The specification is a written description of the invention or discovery and of the manner and process of making, constructing, compounding, and using the same, and is required to be in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which the invention or discovery apper-

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[6] Excerpted from Joseph Rossman, *The Law of Patents for Chemists*, Washington, D. C., 1932, p. 107

tains, or with which it is most nearly connected, to make, construct, compound, and use the same.

"The specification must set forth the precise invention for which a patent is solicited, and explain the principle thereof, and the best mode in which the applicant has contemplated applying that principle, in such manner as to distinguish it from other inventions.

"In case of a mere improvement, the specification must particularly point out the parts to which the improvement relates, and must by explicit language distinguish between what is old and what is claimed as new; and the description and the drawings, as well as the claims, should be confined to the specific improvement and such parts as necessarily co-operate with it.

"The specification must conclude with a specific and distinct claim or claims of the part, improvement, or combination which the applicant regards as his invention or discovery.

"When there are drawings, the description shall refer to the different views by figures and to the different parts by letters or numerals (preferably the latter).

"The following order of arrangement should be observed in framing the specification:

(a) Preamble stating the name, citizenship, and residence of the applicant, and the title of the invention
(b) General statement of the object and nature of the invention
(c) Brief description of the several views of the drawing (if the invention admit of such illustration)
(d) Detailed description
(e) Claim or claims
(f) Signature of applicant."

SPECIFICATIONS FOR PATENTS[7]

1

FOR AN ART OR PROCESS

To all whom it may concern:

Be it known that I, ..., a citizen of the United States, residing at ...., in the county of .... and State of .... (or subject, etc), have invented new and useful improvements in processes of extracting gold from its ores, of which the following is a specification:

[7] The following specimens are taken from the *Rules of Practice* of the United States Patent Office, Washington, 1931, pp. 60 ff. The illustrations referred to in the specimens have not been included here.

This invention relates to the process of extracting gold from its ores by means of a solution of cyanide of an alkali or alkaline earth, and has for its object to render the process more expeditious and considerably cheaper.

In extracting gold from its ores by means of a solution of cyanide of potassium, sodium, barium, etc, the simultaneous oxidation of the gold is necessary, and this has hitherto been effected by the action of the air upon the gold which is rendered oxidizable thereby by the action of the cyanide solution.

Instead of depending solely upon the agency of the air for the oxidizing action, I employ, to assist the oxidation of the gold, ferricyanide of potassium or another ferricyanogen salt of an alkali or of an earth alkali in an alkaline solution. By this means the oxidation, being rendered very much more energetic, is effected with a considerably smaller quantity of the solvent. Thus, by the addition of ferricyanide of potassium or other ferricyanides to the cyanide of potassium solution, as much as eighty per cent of potassium cyanide may be saved.

It may be remarked that the ferricyanide of potassium alone will not dissolve the gold and does not therefore come under the category of a solvent hitherto employed in processes of extraction. It does not therefore render unnecessary the employment of the simple cyanide as a solvent, but only reduces the amount required owing to the capacity of the ferricyanide to assist the air to rapidly oxidize the gold in the presence of the simple salt. Consequently the cyanogen of the latter is not used to form the gold cyanide compound.

I claim:

The process of extracting gold from its ores consisting in subjecting the ores to the dissolving action of cyanide of potassium in the presence of ferricyanide of potassium, substantially as herein described.

2

FOR A MACHINE

To all whom it may concern:

Be it known that I, ..., a citizen of the United States, residing at . . . . ., in the county of . . . . . and State of . . . . . (or subject, etc), have invented a new and useful meat-chopping machine, of which the following is a specification:

My invention relates to improvements in meat-chopping machines in which vertically reciprocating knives operate in conjunction with a rotating chopping-block. And the objects of my improvement are, first, to provide a continuously lubricated bearing for the block; second, to afford facilities for the proper adjustment

of the knives independently of each other in respect to the face of the block; and, third, to reduce the friction of the reciprocating rod which carries the knives.

I attain these objects by the mechanism illustrated in the accompanying drawing, in which—

Figure 1 is a vertical section of the entire machine; Fig. 2, a plan view of the machine as it appears after the removal of the chopping-block and knives; Fig. 3, a vertical section of a part of the machine on the line 3 3, Fig. 2; and Fig. 4, a detailed view in perspective of the reciprocating crosshead and its knives.

Similar numerals refer to similar parts in the several views.

The table or plate 1, its legs or standards 2 2, and the hanger 3, secured to the underside of the table, constitute the framework of the machine. In the hanger 3 turns the shaft 4, carrying a fly-wheel 5, to the hub of which is attached a crank 6, and a crank-pin 7, connected by a link 8, to a pin passing through a crosshead 9, and to the latter is secured a rod 10, having at its upper end a crosshead 11, carrying the adjustable chopping knives, 12 12, referred to hereinafter.

The crosshead 9, reciprocated by the shaft 4, is provided with anti-friction rollers 13 13, adapted to guides 14 14, secured to the underside of the table 1, so that the reciprocation of this crosshead may be accompanied with as little friction as possible.

To the underside of a wooden chopping-block 15 is secured an annular rib 16, adapted to and bearing in an annular groove 17 in the table 1. (See Figs. 1 and 2.) This annular groove or channel is not of the same depth throughout, but communicates at one or more points (two in the present instance) with pockets or receptacles 18 18 wider than the groove and containing supplies of oil, in contact with which the rib 16 rotates, so that the continuous lubrication of the groove and rib is assured. The rod 10 passes through and is guided by a central stand 19, secured to the table 1, and projecting through a central opening in the chopping-block without being in contact therewith, the upper portion of the said stand being contained within a cover 20, which is secured to the block, and which prevents particles of meat from escaping through the central opening of the same.

The crosshead 11, previously referred to, and shown in perspective in Fig. 4, is vertically adjustable on the rod 10, and can be retained after adjustment by a set-screw 21, the upper end of the rod being threaded for the reception of nuts 22, which resist the shocks imparted to the crosshead when the knives are brought into violent contact with the meat or the chopping-block.

The knives 12 12 are adjustable independently of each other and of the said crosshead, so that the coincidence of the cutting-

edge of each knife with the face of the chopping-block may always be assured.

I prefer to carry out this feature of my invention in the manner shown in Fig. 4, where it will be seen that two screw-rods 23 23 rise vertically from the back of each knife and pass through lugs 24 24 on the crosshead, each rod being furnished with two nuts, one above and the other below the lug through which it passes. The most accurate adjustment of the knives can be effected by the manipulation of these nuts.

A circular casing 25 is secured to the chopping-block, so as to form on the same a trough 26 for keeping the meat within proper bounds; and on the edge of the annular rib 16, secured to the bottom of the block, are teeth 27, for receiving those of a pinion 28, which may be driven by the shaft 4 through the medium of any suitable system of gearing, that shown in the drawing forming no part of my present invention.

This shaft 4 may be driven by a belt passing round the pulleys 29, or it may be driven by hand from a shaft 30, furnished at one end with a handle 31, and at the other with a cog-wheel 32, gearing into a pinion on the said shaft 4.

A platform 33 may be hinged, as at 34, to one edge of the table 1, to support a vessel in which the chopped meat can be deposited. The means by which it may be supported are shown in full lines, and the most convenient method of disposing of it when not in use is shown in dotted lines, in Fig. 1.

I am aware that prior to my invention meat-chopping machines have been made with vertically-reciprocating knives operating in conjunction with rotating chopping-blocks. I therefore do not claim such a combination broadly; but

I claim:

1 The combination, in a meat-chopping machine, of a rotary chopping-block having an annular rib, with a table having an annular recess to receive said rib, and a pocket communicating with the said recess, all substantially as set forth.

2 In a meat-chopping machine, the combination of a rotary chopping-block with a reciprocating crosshead carrying knives, each of which is vertically adjustable on the said crosshead independently of the others, substantially as described.

3 A chopping knife having two screw rods projecting perpendicularly from its back and parallel with the sides of the knife.

4 A meat-chopping machine provided with a rod carrying chopping knives and adapted to be reciprocated, a crosshead secured to said rod, anti-friction rollers mounted on the crosshead, and guides with which the rollers cooperate, substantially as described.

3

FOR A COMPOSITION OF MATTER

To all whom it may concern:

Be it known that I, ..., a citizen of ...., residing at ......, in the county of ...... and State of ...... (or subject of, etc), have invented a new and useful Non-Conducting Plastic Composition, of which the following is a specification.

The object of my invention is the production of a plastic non-conducting composition or cement to be applied to the surfaces of steam-boilers and steam-pipes and other receptacles and conduits as a lagging for preventing radiation of heat and the permeation of water, and rendering them fireproof.

My composition consists of a mixture of paper-pulp or other vegetable fibrous material, a powdered mineral filler, such as soapstone or Portland cement, a mineral fibrous material, such as asbestos, and a mineral cementing material, such as silicate of sodium or potassium (soluble glass).

In preparing the composition I prefer to use the ingredients in about the following proportions—viz, fifty pounds of paper-pulp, fifty pounds of soapstone, twenty-five pounds of asbestos, and three quarts of 33° Baumé solution of soluble glass. Good results may be obtained, however, when the ingredients are varied within the following limits: vegetable fibrous material, forty to sixty pounds; powdered mineral filler, forty-five to fifty-five pounds; mineral fibrous material, twenty to thirty pounds; soluble glass, two to four quarts of a 30° Baumé to 35° Baumé solution.

The asbestos may in some cases be omitted when a cheaper product is desired, though the composition is not then so efficient for the lagging of surfaces subjected to high temperatures.

These ingredients are mixed with a quantity of water sufficient to form a paste or mortar of such consistency as to enable it to be plastered over the surface to be protected. It may be applied in one or more coats or layers, in the ordinary manner, according to the nature of the article and the amount of protection required.

My composition is light, fireproof, efficient as a non-conductor of heat, impervious to water, adheres without cracking when it dries to the surface to which it is applied, and possesses in a high degree all the desired properties of a lagging for steam-heated surfaces.

I claim:

1 A plastic composition adapted to form a lightweight, fireproof, and waterproof lagging for steam-heated surfaces, comprising a vegetable fibrous material, a mineral filler in powdered form, and a mineral cementing substance.

2 A plastic composition adapted to form a lagging for steam pipes and the like comprising forty to sixty pounds of paper-pulp, forty-five to fifty-five pounds of powdered soapstone, and two to four quarts of a 30° Baumé to 35° Baumé solution of soluble glass.

3 A plastic composition consisting of a vegetable fibrous material, a powdered mineral filler, a mineral fibrous material, and a mineral cementing substance substantially as described.

4 A plastic composition consisting of fifty pounds of paper-pulp, fifty pounds of powdered soapstone, twenty-five pounds of asbestos fiber, and three quarts of 33° Baumé solution of soluble glass.

Exercises

A Write proposal advertisement, specifications proper, proposal, and contract for

1 Construction of walks or drives on the college campus
2 Drainage of the college grounds
3 Wiring of a building
4 Erection of a piece of machinery
5 Laying of a concrete foundation
6 Construction of a small bridge
7 Laying of the foundation for a direct-connected engine and generator
8 Rearrangement of machinery in shop
9 Installation of fire apparatus
10 Erection of a grandstand on the athletic field
11 Building of a half-mile track
12 Wiring of a direct-current feeder panel
13 Construction of a marble or slate switchboard
14 Installation of a direct-current or alternating-current generator and auxiliary apparatus, such as switches, circuit breakers, instruments, field exciter, etc
15 Installation of a battery-charging outfit for operation on a 3-phase, 60-cycle, 115-volt circuit
16 Installation of an arc-lighting system for a small town
17 Erection of a 10-kw, single-phase, 60-cycle, 110-volt, direct-current converter

B Write a set of manufacturer's specifications (including design, manufacture, and delivery) for a simple instrument or piece of apparatus or equipment.

C Write a set of specifications with claims for a patent.[8]

[8] The student may consult the *Rules of Practice* of the United States Patent Office, 1939, and Joseph Rossman, *The Law of Patents for Chemists*, second edition, Washington, 1934.

APPENDIX A

Preparation of Manuscript and Correction of Proof

Preparation of a Manuscript

The writer should send in manuscript exactly as he wishes it to be printed. Care for details will save expense and labor in the setting up and in the correction of proof.

Use white paper of uniform size, preferably about 8 or 8½ inches wide by 11 inches long. Leave a margin of an inch or an inch and a half at the left and at the top of each page and at least a half-inch margin at the right.

Write on one side of the page only, using black ink. Pages should be numbered consecutively from beginning to end. Copy should be sent flat—that is, not folded or rolled. If possible, the manuscript should be typewritten. Indicate kinds and sizes of type for headings, body of the text, and quoted matter.

Suggestions for Correction of Proof

Proof should be corrected with extreme care. First proof, or galley proof, whether the only proof submitted or not, should be read over twice, to be sure that no errors have been passed by. Mark corrections so that the printer knows exactly what change is to be made. Always return the copy with the proof.

PROOF MARKS

⊙ Period
^, Comma
; Semicolon
: Colon
=/ Hyphen
$\frac{1}{m}$ Dash—one *em* in length
' Apostrophe
'/' "/" Quotations, single or double

∧ Caret—left out, insert
□ Indent one *em*
Insert space
⌣ Less space
lead Add lead, a thin metal strip used to widen the space between the lines
⊂ Close up
𝟿 Letter upside down
ꝺ Delete—take out
center Put in middle of page, or line
tr Transpose
⊏ ⊐ Move to left or to right
⊔ ⊓ Move down or move up
stet Let it stand (with dotted line beneath words referred to)
× Defective type
wf Wrong font
caps Capitals
sm caps Small capitals
〰〰 Bold-faced type letters
lc Lower case—change from capital to small letter
ital Italic
rom Roman
¶ Paragraph
no ¶ No paragraph
eq # Equalize spacing
═ Straighten
// Straighten type line at the side of the page
$\vee$ $\wedge$ ^{a} or $_{1}$ Superior or inferior
[/] Brackets
ⓘ Query. Is this right?

UNCORRECTED PROOF

□ General Requirements. "It is not within =
k/ the scope of a worh such as this nor have the ;/
rom trade conditions in the *heating* busniess ad- *tr*
vanced to such a point, that all the details of
ꝺ/*wf* any ~~any~~ or every sy/tem can be provided for ⊙
× The following proposed form for uniform
standard specifications, however, covers the

ground as fully as can be done at this time, as
is shown by the recomendation by the national
association of Manufacturers of Heatjng Ap-
paratus, and if generally accepted by heating
contractors, manufacturers, architects, invest-
ors, and the <u>layman</u> installing steam or hot
water heating apparatus, would result in a
higher Standard of excellence. Much trouble
now exists in securing ~~the~~ best resultsowing to
ignorance on part of owner, architect or con-
tractor, as well as to unfair competition or
unauthorized substitutions of cheap materials.
Any specifications should set forth unequivo-
cally and in detail as far as feasible all that the
contractor is to fur nish and exactly what is to
be accomplished by his guarantee, which should
embody of economy as well as one of efficiency.
The function the of owner or architect is to
stipulate what results must be accomplished ac-
cording to standards in accepted use, and to
give the consulting engineer (when character
of heating plant demands one or the contractor
proper latitude as to <u>methods</u> to be pursued.
Further than this it is the office of owner or
architect, in justice to himself and to competing
bidders, as well as to the successful contractor,
to see that the provisions of the specifications
are caried and that the quantity and character
of material agreed upon are actually fur-
nishedand used.

CORRECTED PROOF

General Requirements. "It is not within the scope of a work such as this, nor have the trade conditions in the heating business advanced to such a point, that all the details of any or every system can be provided for. The following proposed form for uniform standard specifications, however, covers the ground as fully as can be done at this time, as is shown by the recommendation by the National Association of Manufacturers of Heating Apparatus, and if generally accepted by heating contractors,

manufacturers, architects, investors, and the laymen installing steam or hot-water heating apparatus, would result in a higher standard of excellence. Much trouble now exists in securing best results, owing to ignorance on part of owner, architect, or contractor, as well as to unfair competition or unauthorized substitutions of 'cheap' materials.

"Any specification should set forth unequivocally and in detail (as far as feasible) all that the contractor is to furnish and exactly what is to be accomplished by his guarantee, which should embody a standard of economy as well as one of efficiency. The function of the owner or architect is to stipulate what results must be accomplished according to standards in accepted use, and to give the consulting engineer (when character of heating-plant demands one) or the contractor proper latitude as to *methods* to be pursued. Further than this it is the office of owner or architect, in justice to himself and to competing bidders, as well as to the successful contractor, to see that the provisions of the specifications are carried out, and that the quantity and character of material agreed upon are actually furnished and used."

APPENDIX B

Public Speaking

The Engineer's Manual of English concerns itself primarily with writing. This appendix on Public Speaking is presented for the benefit of teachers, students, and other users of the book who may be called upon to speak in public.

Reference is made here first to Professor S. Marion Tucker's comprehensive treatment of the subject in his *Public Speaking for Technical Men* (McGraw-Hill, 1939). The book will be profitable and fascinating to any engineer who must face an audience, small or large, technical or popular, indifferent or sympathetic. Special attention is directed to the following chapters:

1 The Story of a Day's Speaking at the Convention
3 Our Principal Faults as Speakers
8 Opening the Speech
9 Making Contact with the Audience
13 Personality of the Speaker
17 The Voice of the Speaker as an Asset or a Liability
21 Organizing the Speech
25 Making our Meaning Clear
28 Learning How to Speak: A Symposium of Experiences
30 Morrison Prepares a Speech
31 Morrison Makes his Speech

There follow five excerpts from other discussions of practical speaking. For other treatises on speech and public speaking, the reader is referred to the Bibliography, page 497. The new brief edition of Monroe's standard text, listed there, was developed especially for "practical" courses.

EXCERPT A

PRACTICAL SUGGESTIONS[1]

1 When you apply for a job, the way you talk, how you say what you have to say, and how you listen, have as much to do

[1] J. M. Clapp, *Talking Business*, The Ronald Press Co., 1920, pp. 3-463

with your success as the "credentials" you carry in your pocket.

2 Don't open your mouth until you have something to say.

3 Whatever you have to say, wherever you are, adapt your message to the person you are addressing.

4 Do not use slang.

- a It does not convey the exact thought.
- b It stunts your command of real words.
- c It suggests that you are not careful in your thinking.

5 Use as a rule short sentences. Think your sentence through before you begin. When you do begin, go right through. Between sentences pause as long as you like.

6 Speak distinctly. Do not mumble your words and make people ask you to repeat. Speak in a tone that is clear and pleasant.

7 Remember to keep still. Do not walk about. Do not fidget. Do not put your hands in your pockets, or hook them up behind or in front. Just let them hang down at your sides where heaven meant them to be. (See, however, suggestion 10, page 455.)

EXCERPT B

HINTS TO ENGINEERS ON PUBLIC SPEAKING[2]

1 Don't apologize for your presence as a speaker. If any apologies are needed, let the management make them.

2 Don't tell the audience you are a poor speaker. If it is true, it will be found out soon enough.

3 Be brief. The orator who preceded Abraham Lincoln on the program at Gettysburg talked over two hours; today we don't remember who he was or what he said; Lincoln spoke a few words, and those immortal thoughts are a part of the life of every American. Draw your own conclusions.

4 Marshal your facts. The best extemporaneous speakers are those who have planned in advance what they intend to say and how best to say it.

5 Make every word hit the mark. If a word is not necessary, don't use it. You are not singing a swan song; you are presenting engineering facts.

6 Be heard! If you prepare the best information of the day, and then smother it by swallowing your voice, mumbling your words, and slurring your syllables, your effort will be a rank failure. Every engineer can yell cross section readings for six hundred feet; he can therefore make himself heard by a thousand people. If you are too quiet, the appointed coach in the rear will yell "louder."

[2] These hints were suggested to speakers at the Illinois Short Course in Highway Engineering.

7 Keep within your time limit. The other fellow may have a few valuable things to say also.

EXCERPT C

GUIDE TO SPEAKERS[3]

The following twelve suggestions are directed to authors who are planning to present technical papers before an audience:

1 Refrain from reading a manuscript or using detailed notes; use, instead, brief notes on (few) cards. Avoid the use of cards larger than about 5 by 8 in. and number the cards to avoid confusion and delays during the presentation.

2 Good speaking requires thorough preparation and a good outline with which the speaker is familiar.

3 Try out the microphone or other loud-speaker unit before or at the first of the talk.

4 Make certain that there is adequate light to read notes even when the room is darkened for the display of slides.

5 Practice speaking the words of the abstract to be given before the presentation; this will familiarize you with the facts and their order.

6 Talk and enunciate clearly and distinctly.

7 Do not digress into meaningless details or irrelevancies.

8 Use short sentences; long, involved sentences are not generally understandable and, at best, are difficult to follow.

9 Delivery should be conversational; presenting a technical paper is no place for oratory.

10 Vary your pose; move around, within a small compass.

11 Hold up your head; open your mouth; use your vocal cords, lips, tongue correctly; keep your voice up at the end of sentences.

12 Don't be afraid of grammatical errors or choice of the wrong word; your audience is not that critical, and your manuscript, as published, will be correct.

EXCERPT D

ON THE READING OF SCIENTIFIC PAPERS[4]

Professor DuBois comments on six "audience enemies":

1 The Mumbler—who is handicapped by poor habits of speech, an incorrectly placed voice, or else an inherent nervousness. He

[3] Reprinted from *Transactions of American Institute of Chemical Engineers*, Vol. 37, No. 5, p. 1377

[4] Eugene F. DuBois, *Chemical and Engineering News*, April 10, 1942, pp. 480-481. See also *Science*, New Series, Vol. 95, No. 2463 (March 13, 1942), p. 273.

drops his voice to emphasize important points or else talks to the lantern screen instead of to the audience.

2 The Slide Crowder—who packs his slides with typewritten data and shows too many slides. A good slide needs no pointer or verbal explanation.

3 The Time Ignorer—who talks beyond the limit specified in the program or justified by common courtesy.

4 The Sloppy Arranger—who jumbles his material. Instead of trying to lead up to a climax and hold the audience in breathless suspense, he would do better to follow newspaper technique and give in headline, early in the talk, some idea as to what and wherefore.

5 The Lean Producer—who has poor material. The real audience enemy is the man whose paper consists of trivia, errata, omissia, et cetera; mostly et cetera.

6 The Grasping Discusser—who when he gets talking stays talking.

The time to start training, says Professor DuBois, is when a man is young. A proper delivery technique should allow both speaker and audience to forget the delivery and concentrate on the subject matter.

EXCERPT E

PRACTICAL PUBLIC SPEAKING[5]

This section in *The Officer's Guide* is directed specifically to officers in the Army. The admirable practical treatment of the subject of public speaking that appears in this *Guide* applies, however, almost as pertinently to the layman as to the military man. In the following condensed summarizing abstract, an attempt is made to present the chief points of the chapter.

1 Purpose of an Address—to inform, to instruct, to convince, to inspire, to interest

2 Speech in the Instructional Process—six steps in the general Army system of training which apply to speech as well as to other subjects:

a Preparation by the instructor
b Explanation of the work to be undertaken
c Demonstration

[5] *The Officer's Guide*, ninth edition, The Military Science Publishing Company, Harrisburg, Pa., 1942, pp. 413-420

- d Application, or practical work
- e Critique
- f Testing

3 The Importance of Preparation
- a Most important step in the whole process
- b Good speakers generally painstaking students, patient analysts, skillful organizers

4 Outlining the Subject
- a Preliminary outline useful
- b Good way to start is to write down, with no particular attention to the order, the distinct points which should be included. Then consider each critically and delete ruthlessly those not strictly essential. Then decide on the logical sequence. Finally, list the important items under each separate entry.

5 Writing the Speech
- a Often not necessary—if officer-instructor is fluent in his specialties
- b At the service school—different conditions: class may be large, subject extensive, time sharply limited; then better for speaker to write out exactly what he wishes to say.

6 Introduction
- a Must define the subject
- b Must link interest of audience to the subject
- c Must excite curiosity
- d Often should identify the speaker as one qualified to discuss the subject

EXAMPLE—BAD

My subject is China, etc. It is a big country and a big subject. In the short time at my disposal I cannot tell you very much about it. I will tell you some of my observations.

EXAMPLE—GOOD

My subject is the situation which faces the people of China. For four interesting years I have lived in that unhappy country as a language student. The experience enabled me to become acquainted with many Chinese people, to see them in their homes, watch their activities, and learn a little about their aspirations. Our nation has many interests in China which are being threatened and undermined today. Those interests affect each of you, etc.

7 Words, Sentences, Paragraphs
- a Choose direct, simple, uninvolved expressions.
- b Choose words which the audience will surely understand.
- c Avoid the vulgar and profane.
- d Veer to the short side in sentence structure.
- e Start new sentences instead of linking an interminable series of thoughts with "ands" and "buts."
- f Make each sentence express a distinct thought.
- g Start each paragraph with a topic sentence.
- h Build it up and drive it home.
- i Close with a sentence which emphasizes or summarizes the statements in the paragraph.

8 Instructional Aids
- a Large-scale wall maps
- b Blackboard
- c A model
- d Lantern slides and strip films
- e Motion pictures
- f Demonstration

9 Value of illustrative examples—used freely to illustrate abstract principles

10 Value of repetition

11 Rehearsal
- a Developing of confidence, final choice of words, test of timing, technique in presentation
- b Opportunity for speaker to ask questions addressed to himself:
  - (1) Is it clearly expressed?
  - (2) Is it convincing?
  - (3) Are important points adequately stressed?
  - (4) Are nonessentials included which are better omitted?
  - (5) Does it express my exact intentions?
  - (6) Are there statements capable of misinterpretation?
  - (7) Are there awkward phrases or difficult passages?
  - (8) Does it accomplish my mission?

12 Interest Factors
- a Choose places for delivery of oral instruction which are free from sounds or sights which detract from attention.
- b Don't use disturbing mannerisms—
  - (1) Stand erect but not stiffly.
  - (2) Move about only when there is a purpose to movement.

(3) Use gestures only when they are natural or instructive.
(4) Face the audience and look at it.
(5) When necessary to use a pointer, stand with your side to the chart.
(6) Avoid nervous movements of the hands.

13 Means of Obtaining Emphasis
a Define, illustrate, build up each point.
b Avoid monotone—change pitch or volume and time or rate of delivery.
c Stop occasionally to ask a question which requires an answer by a designated student.

14 Volume—not too loud or too low

15 Length—good training to see what can be done with a difficult subjcct in 15 minutes

16 Final Rule—have something to say; say it; sit down.

APPENDIX C

Correspondence, Orders, Reports of the Departments of War, Navy, and State

War Department[1]

I MILITARY LETTERS

A Original Communication

1. One subject. An official communication other than a cablegram will, in general, refer to one subject only.

2. One side of sheet. Except in using prescribed forms or in reproducing material by mimeograph, multilith, etc., one side of a sheet only will be used in all communications and enclosures.

3. Letter-size paper. For all letters, for indorsements generally, and for all reports with reference to individuals, except reports made on prescribed blank forms, the paper used will be 8 by 10½ inches.

4. Unused margins. Unused margins of the following widths will be left in each communication:

a. At top:
   (1) First page, 1 inch.
   (2) Second and succeeding pages, 1¼ inches.

b. At left, 1¼ inches.

c. At right, ¾ inch.

d. At bottom, 1 inch excluding page number which will be ½ inch from the bottom as indicated in paragraph 27.

5. Page numbering. The pages of a communication will be

[1] The following statements represent excerpts from Army Regulations Bulletin No. 340-15, *Correspondence*, August 21, 1942. Apart from the abbreviation or omission of some of the sections (sections which appear to be too technical to justify inclusion in a book of this nature), the excerpted sections are reproduced with exactness from the Government Regulations. Some apparent inconsistencies in the outline symbols naturally result.

Supplementing these regulations, is the section on Personnel Correspondence in the *Technical Manual*, T M 12-250, from which excerpts follow immediately, pp. 472 ff.

numbered consecutively in a single series, midway, about ½ inch from the bottom.

6. Spacing. When typewritten, the body of an indorsement or a letter will be single spaced with a double space between numbered paragraphs. A letter consisting of less than eight lines may be double spaced.

7. Paragraphing. *a. Uniformity.* The system prescribed herein will be used for all military communications and publications whether typewritten or printed. When consisting of many paragraphs, two or more may be grouped into sections and/or chapters in logical accordance with the subject matter.

b. Indentation. Paragraphs will be indented five spaces. Subparagraphs or primary divisions will also be indented five spaces and their designations will appear directly under the paragraph number, except where the first such division is likewise the first part of the paragraph as in *a* above. Subdivisions of subdivisions will be further indented five spaces.

c. Designations.

(1) Paragraphs, if more than one, will be numbered in a single series of Arabic numerals.

(2) Subparagraphs, or primary divisions, of each paragraph will be designated by the underscored lower-case letters, as a, b, z, aa, az, ba, etc.

(3) Subdivisions of primary divisions will be designated by Arabic numerals in parentheses, as (1), (2), (3), etc.

(4) Subdivisions of subdivisions will be designated by underscored lower-case letters in parentheses, as (a), (b), (c), etc.

(5) Further subdivisions will be avoided, but when used will be designated by underscored Arabic numerals as 1, 2, 3, etc.

(6) In printed matter, the underscored designations will be in italics.

d. Illustration. The foregoing rules are illustrated below, 3 being the assumed number of the paragraph:

3. Subject of paragraph.—a ....

b. Subject, if any, of subparagraph.—(1) ....

(2) ....

(a) ....

(b) ....

1. ....

2. ....

<u>c</u>. ....
<u>d</u>. (1) ....
(2) ....
<u>e</u>. ....
<u>f</u>. ....
....
<u>z</u>. ....
<u>aa</u>. ....
....
<u>az</u>. ....

8. Abbreviations. Maximum use will be made of authorized abbreviations. See AR 850-150 and FM 21-30.

9. Heading. *a. General.* For all letters to be signed by a subordinate for or by order of a chief of service, or bureau, or for or by command or order of a commander or other similar official, the letter heading used will be that of the headquarters and office of such chief, commander, or other official.

b. Contents.

(1) The upper third of the first sheet less the part 1-inch from the top will, except in immediate action letters, be devoted to—

(*a*) The heading of the letter only, containing—

1. Designation of the headquarters, or
2. Designation of the office.
3. If desired, at the upper left, a brief request for reference to the file number in making reply, including the file number and such additional identifying matter as may be desirable. If the letter consists of more than one page, the file number will be similarly placed on each page.
4. At the upper right corner of the file copy the identifying initials of the person dictating and of the person typing the letter.
5. Post office address.
6. Date.
7. The word SUBJECT, followed by a brief statement of the subject matter.
8. The word TO, followed by the official designation, or grade, name, organization, or arm or service of the person addressed, followed when necessary by the post office address written underneath.

(*b*) *Examples.*

1. JWD-RWR

HEADQUARTERS SECOND SERVICE COMMAND

Office of the Commanding General

In reply refer to: Governors Island, N. Y.

062.12 February 1, 1942

SUBJECT: Training literature

TO: The Adjutant General,
Washington, D. C.

2. JD-RR

HEADQUARTERS SEVENTEENTH INFANTRY

Office of the Regimental Commander

In reply refer to: Governors Island, N. Y.

201, Doe, John W. February 1, 1942

SUBJECT: Discharge of above-named

TO: Commanding General,
Second Service Command,
Governors Island, N. Y.

3. JWD-RWR

COMPANY G, SEVENTH INFANTRY

In reply refer to: Fort Crook, Nebr., February 1, 1941

56

SUBJECT: Loss of company funds

TO: Commanding Officer,
17th Infantry,
Fort Crook, Nebr.

(2) (*a*) The heading of a letter from an individual writing as such will contain the following, arranged as indicated in (*b*) below:

1. Post office address
2. Date
3. "Subject" and "To" each followed as specified in (1) (*a*) 7 and 8 above.

(*b*) *Example.*

Fort Crook, Nebr.,
February 1, 1942

SUBJECT: Leave of absence
TO: Commanding Officer, Fort Crook, Nebr.

(*c*) *Arrangement.* When the window envelope is used the matter prescribed above will be so arranged and placed that when the letter is folded as prescribed (see par. 40) and placed in the envelope the address only will be visible.

10. Body. The body of the letter will begin below the upper one-third of the sheet.

11. Salutation; complimentary close. *a. Salutation.* A salutation, such as "Sir," "I have the honor," "I would respectfully," will not be used.

b. Complimentary close. A complimentary close, such as "Respectfully," "Very respectfully," etc., will not be used.

12. Use of "By command of"; "By order of"; "For." When a subordinate signs a communication for a chief of service or bureau, or a commander, or other similar official, and the authority by which the communication is made does not sufficiently appear in the body of the communication, the appropriate one of the following forms will appear on the communication between the body thereof and the signature. (See AR 310-50.) Abbreviations will not be used.

a. In communications to subordinates (for signature see par. 37b):

"By command of..........;" or "By order of..........:"
By command of Lieutenant General ....:
By order of Colonel ....:
By order of Major ....:

b. In other communications, except communications to Members of Congress (for signature see par. 37b):

For the Commanding General:
For the Regimental Commander:
For the Commanding Officer:

13. Signatures.—*a. General.*

(1) The body of a communication or, when used, the "By

command of" or "By order of ....," or "For ....," will be followed by the signature, except that routine indorsements on communications passing between offices of the same headquarters may pass unsigned.

Signature will be made with pen or, when necessary in the field or otherwise, with indelible pencil, but never by facsimile.

Signatures *will be plainly and legibly* written.

(2) (*a*) The signature will ordinarily consist of the first name, middle initial, and last name.

(*b*) The signature of an enlisted man will always consist of his first name, middle initial, and last name, followed by his Army serial number.

(*c*) The signature, if any, on routine indorsements referring, transmitting, forwarding, and returning papers will consist of the initials only.

14. How arranged and fastened. *a. For other than filing.*

(1) Original with pages in numerical sequence followed by original indorsements in numerical sequence, except that the last indorsement with copy thereof with pages in numerical sequence will be on top.

(2) Copy or copies of the basic communications followed by copy or copies of indorsements except the last in numerical sequence.

(3) Inclosures in numerical sequence.

b. For filing. The several parts of a communication will ordinarily be similarly arranged and fastened together, except that the last original indorsement will follow immediately the other original indorsements.

c. Fastening.—Fastening will be such as to—

(1) Insure against casual separation of the parts.

(2) Permit intentional separation without mutilation. Pins will not ordinarily be used.

15. Copies.—*a. Number and contents.*—A letter or indorsement to an office or individual in or under the War or Navy Department will be made with two copies.

16. Folding.—*a.* Letter paper will ordinarily be folded in three equal folds, parallel with the bottom, the lower fold over the face of the letter and the top fold toward the back of the letter.

b. When several communications are to be mailed at the same time to one address, they will, so far as practicable, be mailed together, unfolded, in one envelope marked "Letter Mail."

B Indorsements

1. General. *a. Definition.* An indorsement is the particular form of reply used for military correspondence. The recipient of a military letter requiring an answer does not ordinarily keep the letter and reply to it with another; instead a reply is appended to the original letter and both are returned to the sender.

b. Numbering. The indorsement on a communication will be numbered with Arabic numerals in a single series beginning with 1st.

2. Written. *a. Where and how placed.* The writing width of written indorsements will be the same as that of the letter. The first written indorsement will begin about ½ inch below the lowest element of the next preceding matter on the same page, and succeeding written indorsements will follow one another serially, with a space of about ½ inch between indorsements on the same page.

b. Contents.

(1) In preparing a written indorsement the items enumerated below will be in the sequence and in the general manner indicated below:

(*a*) File number of the communication, including necessary additional identifying matter.
(*b*) Serial number of the indorsement.
(*c*) Identifying initials of the person dictating and of the person typing the indorsement. These initials may be placed elsewhere or omitted.
(*d*) Official designation of the headquarters and the office by which the indorsement is being sent.
(*e*) Name of the place from which the indorsement is being sent.
(*f*) Date.
(*g*) The word "To," followed by the official designation of the person to whom the indorsement is being sent, or if being sent to an individual, his grade, name, organization, or arm or service.
(*h*) Post office address of the addressee, if necessary.

(2) For examples of written indorsements see paragraph 41, AR340-15.

c. Arrangement. The foregoing will be followed by the body, if any, of the indorsement, beginning, when typewritten, two spaces below. Such expressions as "Referred," "Transmitted," "Forwarded," and "Returned" will not be used. The expression "Not favorably considered" instead of "Disapproved" will be used when addressing a general officer.

d. Signatures. For concluding parts of and signatures on indorsements, see paragraphs 36 and 37, AR340-15.

e. Copies. For copies of indorsements, see paragraph 38, AR340-15.

II NONMILITARY LETTERS

1. General. Official correspondence with offices or individuals not in or under the War Department or the Navy Department will be in the general forms in use in proper civilian practice.

2. Details. *a.* The letter heading (par. 32, AR340-15)—

(1) May contain "In reply, please address official designation or title of office of writer and not his name": at the upper left.

(2) Will not ordinarily contain the form words "Subject" or "To," or the matter prescribed to follow the word "Subject," but when considered desirable may contain these.

(3) Will, as to the address, be—

(*a*) If to an individual as such:

Mr. John W. Doe,
1234 Roe Street,
Chicago, Ill.

(*b*) If to a Representative in Congress:

1. Honorable John W. Doe,
House of Representatives,
Washington, D. C.

2. Honorable John W. Doe,
Representative in Congress,
1234 Roe Street
Chicago, Ill.

(*c*) If to a United States Senator:

1. Honorable John W. Doe,
United States Senate,
Washington, D. C.

2. Honorable John W. Doe,
United States Senator,
1234 Roe Street,
Chicago, Ill.

(*d*) If to the Governor of a State:

Honorable John W. Doe,
Governor of the State of New York,
Albany, N. Y.

b. The body of the letter (par. 34, AR340-15)—

(1) Will be introduced by an appropriate salutation, such

as My dear Sir, Dear Sir, My dear Madam, Dear Madam, (. . . Madam will ordinarily be used in addressing unmarried as well as married women); Dear Senator, My dear Senator, Dear Mr. . . . ., etc.

(2) Will ordinarily contain no paragraph numbers.

(3) Will ordinarily when typewritten be double spaced, unless if so written it would cover more than one page, in which event it may be single spaced.

c. A complimentary close, such as Respectfully yours, Very respectfully yours, Truly yours, Very truly yours, Sincerely yours, will be used.

d. Copies and records (pars. 38 and 39, AR340-15). One copy only will ordinarily be made in cases in which the communication is of such character as to warrant retaining a record thereof, or furnishing to some one concerned.

e. Examples of nonmilitary letters and replies thereto—

(1) Letter from individual.

Maran Village, N. H.
May 20, 1942

The General, Camp Madison
New Jersey

Dear General,

I am writing about my husband John, who is a soldier in your camp. His full name is John Baggott, and he is in the one hundredth regiment. He was drafted into the army for one year and was married to me when he was home on furlough in July of last year. He was to be released from the army in January and had a job on a farm here. Now I am told that he cannot be released because there is a war on.

. . . .

You must let my John out of the army, as you said you were going to last July. You didn't do as you promised. He can work here and get our baby special medicines which the doctor says he should have. . . .

Yours truly,

/s/ *Mrs. John Baggott*

Wife of Corporal
John Baggott

201—Baggott, John, 7483264 (Enl) 1st Ind. BC/blr

Hq, Camp Madison, N. J., May 22, 1942.—To Commanding Officer, 100th Infantry, Camp Madison, N. J.

For investigation and direct reply, with report to this office.

By command of Brigadier Ceneral MARTIN:

/s/ *Bernard Carter*
/t/ BERNARD CARTER,
Major, AGD,
Adjutant.

201—Baggott, John 7483264 (Enl) 2d Ind. HGW/ehs

Hq, 100th Infantry, Camp Madison, N. J., May 24, 1942.—To Commanding General, Camp Madison, N. J.

1. First Indorsement complied with.
2. Copy of reply inclosed.

For the commanding officer:

/s/ *Harold G. Walker*
/t/ HAROLD G. WALKER,
Captain, Inf.,
Adjutant.

1 Incl.
Copy of letter to
Mrs. John Baggott.

HEADQUARTERS

100th Infantry

Camp Madison, N. J.,
May 24, 1942

201 (Baggott, John, 7483264)
Mrs. John Baggott, Maran Village, N. H.

My dear Mrs. Baggott:

Your letter to the Commanding General, Camp Madison,

N. J., regarding your husband's discharge has been referred to me for reply.

Because the nation is at war and needs all its trained soldiers, discharges are allowed only under most pressing circumstances.

I have talked with Corporal Baggott and he has arranged to make an allotment to you from his pay of forty-five dollars a month. This will be sent to you direct each month by the disbursing officer.

I hope this will help to solve your problem. If I can be of any further assistance in the future, do not hesitate to write me.

Yours most sincerely,

/s/ *Harold G. Walker*

/t/ HAROLD G. WALKER,
Captain, Inf.,
Adjutant.

(2) Letter to Member of Congress.—Will be sent in duplicate.

HEADQUARTERS

200th ARMORED DIVISION

Fort Bixby, Ariz.,
November 22, 1941

Honorable William Linton Smith,
United States Senator,
New City, Ariz.

My dear Senator Smith:

I wish to take this opportunity to thank you for the courtesy of the informal visit which you made yesterday to this division. Your many interesting questions showed that you are sincerely interested in the development of the Armored Force.

Since you are so genuinely interested in the development of the Armored Force, and since this is the only armored division in the State of Arizona, the officers and men of this command would like to have you as a frequent visitor.
On Saturday, December 6, at nine o'clock the division will

have its first formal review. It would be a distinct privilege to hold this review in your honor.

Very truly yours,

/s/ *A. L. Enhold*
/t/ A. L. ENHOLD,
Major General, U. S. Army,
Commanding.

(3) Letter of condolence.

COMPANY K
100th INFANTRY

Fort Dix, N. J.,
April 30, 1942.

Mrs. John Doe,
144 College Avenue,
Paris, Ill.

Dear Mrs. Doe:

Your son, William, who had been confined in the station hospital, Fort Dix, N. J., for the past few days with lobar pneumonia, died this morning.

You have the deepest sympathy of the officers and men of this organization in your bereavement. William was held in high regard by all members of the command. He was a splendid soldier and an outstanding character. His loss will be deeply felt by his many friends. You may rest assured that everything possible was done for his recovery.

I wish to express my own personal sympathy in your loss. Please feel free to call upon me for any additional information you may desire. I shall write you as soon as possible about certain necessary arrangements.

Yours most sincerely,

/s/ *Martin C. Woodring*
/t/ MARTIN C. WOODRING,
Captain, 100th Inf.,
Commanding.

III PERSONNEL CORRESPONDENCE[2]

a. The composition of letters—and indeed, all written communications—is one of the adjutant's most important responsibilities. Correctness of form, spacing, margins, and neatness in typing are all important. But these are of little moment if the body of the letter or indorsement does not clearly express the meaning which the writer wishes to convey. A knowledge of the rules of syntax and good usage is essential, together with a clear understanding in the mind of the writer of the message to be conveyed. Use good, clear, concise English! Avoid the use of stilted, ponderous, and unusual words and phrases. Make the sentences short and complete. Be sure that sentences and paragraphs are arranged in logical sequence.

Do not use the personal pronoun, except in an official letter concerning yourself; and in that case, do not refer to yourself in the third person.

b. Always be courteous. Never, under any circumstances, resort to sarcasm; be considerate of the feelings of the person to whom the letter is addressed.

c. Deal with only *one* subject in each letter.

d. Answer all communications within 24 hours. If the data necessary for the reply are not at hand and cannot be obtained within 24 hours, the letter should be acknowledged, together with a statement of the reasons why an answer cannot be given and an estimate of the date when a reply may be expected. *Do not forget to make the reply on or before that date.*

Be sure that an IMMEDIATE ACTION letter receives immediate action! If it cannot be answered the same day as received, then an acknowledgment, also on IMMEDIATE ACTION paper, should be sent to the writer, giving the reason for the anticipated delay, and a definite date upon which reply will be made. In your own headquarters use IMMEDIATE ACTION paper sparingly. Be quite sure that the subject matter is of such importance as to demand immediate action. This applies with special force when writing to a higher headquarters. Until you have acquired experience, it is a good plan to show all IMMEDIATE ACTION letters, both received and to be sent, to the executive or commanding officer. When replying to an IMMEDIATE ACTION letter by indorsement, be sure that the first sheet of your indorsement is also IMMEDIATE ACTION paper.

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[2] The following excerpts are from the section entitled Personnel Correspondence, T M 12-250, pp. 226, 227.

Do not reveal the contents of an official communication to any persons other than those concerned. Also be sure that persons on duty in your headquarters understand that they must not reveal the contents of any official communication, nor discuss outside of the office any knowledge which comes to them incident to their employment in the headquarters.

See that indorsements and enclosures are arranged in the proper sequence prescribed in the regulations.

Insist that the exact, prescribed form be followed in the preparation of every letter and indorsement. Require that every correspondence clerk keep a copy of AR 340-15 on his desk for ready reference, and make frequent use of the dictionary. Require the sergeant major or his assistant to check every letter for correctness of form, spelling, and syntax, then check it yourself—at least until correct usage has been established.

Write only when necessary! Within your own organization, use correspondence as little as possible. Use the telephone, or make a personal call instead. Unless the matter is disciplinary in nature and a formal record is required, the informal method of communication is best.

The same principle may be applied in communicating with the division headquarters. The division adjutant general would usually rather answer a question over the telephone or by an informal reference sheet or note. Records may be and often should be made of telephone conversations, and such informal memorandums may be filed.

What is written above about letters applies also to indorsements. There are a few other precautions concerning indorsements. One is against the use of the phrase: "You will explain by indorsement hereon why . . . ." Such phraseology is almost sure to engender resentment in the person to whom the communication is addressed. You would not, under any circumstances, of course, address such a communication to anyone not under the command of your own commander. When a matter becomes so aggravated as to warrant such phraseology, you will, if you are wise, call in the person concerned and obtain the necessary explanation verbally—always remembering to use tact, with firmness! If a reprimand is needed, remember that only the commanding officer himself may administer a reprimand. The authority may not be delegated to any member of the staff. An experienced adjutant may exert pressure—may convey to another officer that the commanding officer is displeased with an apparent failure or dereliction, but he should be very wary of putting such expressions in a letter or indorsement.

A word of advice is appropriate about the authentication and

signature of letters and indorsements. If a letter or indorsement is going *down* in the chain of command, it is authenticated by use of the phrase: "By order of Colonel DOE," with the signature of the adjutant just below that line. If it is going *up*, that is to brigade, division, corps, corps area, or the War Department, the authentication should be: "For the Commanding Officer," with the adjutant's signature following.

Some commanding officers wish to sign all communications going up, but the general practice is for the adjutant to sign all communications except those concerning major policy or of a highly confidential nature, or those having to do with disciplinary action or censure of an officer.

In any case, when you sign a communication as adjutant, your typed name appears below your signature, your grade and arm on the line below that, and the word "Adjutant" below that. The assistant adjutant may sign for you; in which case, his name, grade, and arm are typed, with the words "Asst. Adjutant" on the bottom line.

Do not use the term "we" in official communications. In referring to the regimental commander's wishes or desires, use the expression "the commanding officer" or "this headquarters," if the letter is going up.

IV GENERAL ORDERS AND SPECIAL ORDERS[3]

1 AR 310-50—Military Publications, Orders, Bulletins, Circulars, and Memoranda—is the basic regulation on the subject. This publication should be read, studied, and kept handy for constant reference.

2 The two classes of orders with which a regimental adjutant is most concerned, from the standpoint of their preparation, are general orders and special orders. One type of general orders and one type of special orders have already been shown in Section II, Chapter IX.

General orders will contain matters of importance which are directive in nature, *general* in application, of permanent duration, and not readily susceptible of immediate incorporation in established forms of regulations. Note that phrase "general in application." A general order concerns the entire command. Everybody must comply with it.

Special orders are those orders which concern individuals or groups of individuals constituting parts of a command. The assignment, reassignment, transfer, promotion, and separation of indi-

[3] TM 12-250, pp. 227 ff. and pp. 97-98

viduals are accomplished by special orders. Special orders are also used to place officers and enlisted men on special duty and detached service; to appoint boards of officers, and courts martial. Letter orders may be directed to, and apply to, one or more individuals constituting part of a command. Courts martial are appointed in special orders, but their approved findings and sentences are promulgated by general court-martial orders and special court-martial orders, depending upon whether a general or special court martial is concerned. Findings of summary courts are not published.

3 Within the regiment, regimental special orders are used to effect the transfer, between units of the regiment, of officers, warrant officers, and enlisted men; to effect the promotion of enlisted men to noncommissioned grades, and to announce the demotion of enlisted men; *to appoint boards* of officers; to grant leaves of absence to officers, within the time limits prescribed by higher authority; to place officers and enlisted men on special duty and detached service, where such detached service is for the officers' own convenience and does not involve travel at Government expense. A regiment, serving with and as a part of a tactical division, or as a unit of a post or station, does not issue orders involving travel at Government expense for either officers or enlisted men, unless specifically directed to do so in special cases by higher authority.

4 Military orders—including general, special, general court-martial orders, special court-martial orders, orders, memorandums, circulars, and bulletins—must contain four parts: the heading, the title or designation, the body, and the authentication. Each of these components may and usually does contain more than one element.

5 The heading consists of three parts: the headquarters from which the communication emanates, the location of the headquarters, and the date. In some headquarters it is the practice to include in the second line the name of the office of the commanding officer. However, as the headquarters of any organization *is* the office of the commanding general, or the commanding officer, that subordinate designation is commonly used only for those communications which are signed by the commanding officer personally. Example:

HEADQUARTERS, 100th INFANTRY
FORT DIX, N. J.

October 24, 1941

6 The title or designation shows the class of order, and the number in series. Example:

SPECIAL ORDERS
No. 96

7 The body of the order is its most important part. In either a general or a special order, the body of the order may contain any number of paragraphs. They are numbered serially from 1 in special orders, and numbered serially within each section in general orders.

8 There is one fundamental rule, evolved by time and experience, which governs the composition of orders—all orders must be *clear, concise,* and *subject only to that interpretation desired by the commander!* The problem is how to attain that ideal of clarity and conciseness. Two processes are involved, the mental and the mechanical. The first involves a clear understanding of what is desired; the second involves a choice of words and phrases, arranged in logical sequence and correctly punctuated, to convey the commander's desire in the clearest manner.

9 The body of an order—that is, each single complete numbered paragraph—should contain six essential elements, either expressed or implied. They are WHAT, WHY, WHEN, HOW, WHERE, and WHO. A good way to fix these six elements in mind is to memorize Kipling's little verse:

> "I keep six honest serving men
> (They taught me all I knew)
> Their names are What and Why and When
> And How and Where and Who."

10 It is not necessary that these six elements appear in that sequence. In fact, they rarely do. But they should all be in the special order, either expressed or implied.

11 The mental process involved in the composition of an order, therefore, involves a determination of *what* is to be done, *who* is to do it, *when* it is to be done, *why* it is to be done, *how* it is to be done.

12 There are certain formulae and certain phrases so long used in War Department orders, and in orders issued by other headquarters throughout the Army, that they have become standard usage, although not specifically required. The best way to become familiar with them is to study examples. (See the specimen order on the next page.)

HEADQUARTERS 100th INFANTRY
FORT DIX, N. J.

September 8, 1941

SPECIAL ORDERS
No. 56

1. CAPTAIN JAMES A. FRY (0000000), 100th Infantry, is hereby relieved from assignment and duty with Company H, 100th Infantry, is assigned to Company C, 100th Infantry, and will assume command.

2. Pursuant to instructions contained in letter, Headquarters 20th Infantry Division, September 5, 1941, Subject: Detail of Enlisted Men to Motor Transport School, file 220.632, Sergeant Frank A. Zombi (000000), Service Company 100th Infantry, will proceed without delay from this station to Holabird, Md., reporting upon arrival thereat to the Commandant, Quartermaster Motor Transport School, for temporary duty as student, for a period of approximately two months unless sooner relieved, and upon completion of such temporary duty, will return to his proper station. The Quartermaster Corps will furnish the necessary transportation. It being impracticable for the Government to furnish cooking facilities for rations en route, the Finance Department will pay in advance the monetary allowance in lieu of rations prescribed in paragraph 2a, Table II, AR 35-4520, as amended by W. D. Circular No. 50, March 26, 1941, at the rate of $3.00 per man per day for one man for one third (1/3) of one day. The travel directed is necessary in the military service. FD 1401 P7-06 A 0410-2.

3. Under the provisions of paragraph 1c (4) (b), AR 345-415, a board of officers is appointed to meet at this station at the call of the senior member thereof, to investigate and report upon all the facts and circumstances leading up to and surrounding the injury sustained by Private James E. Hilton (000000), Company B, 100th Infantry, on or about September 7, 1941, and to determine whether or not such injury was received in line of duty, or was the result of the soldier's own misconduct. The board's report, and all exhibits thereto will be submitted in quintuplicate. The board proceedings and its report will be in accordance with the provisions of AR 420-5. Detail for the board:

CAPTAIN SAM T. JONES (000000), 100th Inf.
1st LIEUT. RAY A. HAMBRICK (000000), M.C.
1st LIEUT. JAY J. POTTER (000000), 100th Inf.

The junior member of the board, other than the medical officer, will act as recorder.

By order of Colonel ATWATER

/t/ Thomas A. DuBois
Captain, 100th Infantry
Adjutant

Official:
/s/ *Thomas A. DuBois*
/t/ Thomas A. DuBois
Captain, 100th Infantry
Adjutant

This is a complete special order. Normally each paragraph would be issued as an "Extract," like this:

HEADQUARTERS 100th INFANTRY
FORT DIX, N. J.

September 8, 1941

SPECIAL ORDERS
No. 56

EXTRACT

1. CAPTAIN JAMES A. FRY (000000), 100th Infantry, is hereby relieved from assignment and duty with Company H, 100th Infantry, is assigned to Company C, 100th Infantry, and will assume command.

By order of Colonel ATWATER

/t/ Thomas A. DuBois
Captain, 100th Infantry
Adjutant

Official:
/s/ *Thomas A. DuBois*
/t/ Thomas A. DuBois
Captain, 100th Infantry
Adjutant

13 Analyze each paragraph of this special order. To begin with, each paragraph is a complete order within itself, when prepared in extract form. That is, the body of the order is complete in each

paragraph. It must contain each of the six essential elements, either expressed or implied. The six "honest serving men" must be there.

14 In the first paragraph, transferring Captain Fry from one company to another, the WHY and HOW elements are implied. The *why* is because the commanding officer directs the transfer. The authority to make such a transfer is inherent in the command function, since the officer already belongs to the regiment, and the transfer is between units of the regiment. Since no travel at public expense is involved, it is not necessary here to state *how* the actual physical transfer will be made. It is implied that Captain Fry will go from one company to the other by walking or riding in his own or Government transportation. The WHEN element is included in the word "hereby" which means "by this instrument" right now, since an order is effective upon issue, except when another date is specifically given in the order. WHAT —he is relieved from Company H; WHERE—in the 100th Infantry which is at Fort Dix; WHO of course is Captain Fry; another WHAT is that he is assigned to Company C.

15 The second paragraph, the one on Sergeant Zombi, contains all of the six elements. Note that first line—"pursuant to instructions contained in . . . ." That is the WHY—the first why; any order directing travel must show the authority therefor. The WHO is Sergeant Zombi. WHAT is to proceed from this station to Holabird, Md. WHEN? Without delay. WHY? For temporary duty as student—this is the second WHY. The second WHAT is "upon completion of this temporary duty will return to his proper station." HOW? "The Quartermaster Corps will furnish the necessary transportation" (also, the payment of ration money). The line, "the travel directed is necessary in the military service. FD . . ." is not one of the six elements required of all orders, but it is a necessary element of every travel order. It is required by statute, before any payment from public funds may be made either for transportation or for reimbursement on a mileage status. And of course the procurement authority must be shown. This is the FD followed by the numbers.

16 The third paragraph also contains the six essential elements. *You* pick them out and write down on a piece of paper each word or phrase which constitutes one of the six elements. Remember that any one of the six may be, and often is, used more than once.

17 Study the phraseology used in these orders. Study every order which comes into your office, and follow those forms which

seem best. And be sure that every order issued by your own headquarters contains all the essential elements.

18 Memorandums and bulletins are used to promulgate directives of a general character and of a more or less temporary nature. They are usually issued in a numbered series, authenticated just as are orders. They resemble orders except for the title, which is "MEMORANDUM NO. ———." Memorandums to the command are generally employed to convey directives, repeat instructions received from higher authority, call for needed special reports. Informal memorandums addressed to individuals are usually signed as are letters.

19 Most commands issue a daily bulletin, which is both directive and informative in character. The directives are usually those of a temporary and transitory nature. The information section usually contains matter not directive in nature, but which it is desired to publish. For instance, the daily bulletin may direct that guard mount for tomorrow be formal, and will list the detail of officer of the day and officer of the guard; the information section may list the attractions to be shown at the post motion picture theater, announce arrivals of officers; list rooms or apartments available for rent in the vicinity, carry a notice of some lost article. In a word, it is an abbreviated daily news sheet for the command. It bears the same heading as orders and is authenticated in the same manner.

20 Orders, memorandums, and bulletins may be authenticated without the actual autographed signature of the adjutant by the use of a metal die seal on extract copies which are written on bond or tissue, and by a rubber stamp facsimile of the seal on mimeographed copies. A rubber stamp facsimile of an officer's signature is never authorized on official documents of any kind. The original must always bear the actual signature of the officer signing the order. This may be accomplished by use of a stylus on the mimeograph stencil.

21 Many commands have local customs regarding authentications and signatures on communications of various types. Here is a good rule to use as a guide in deciding when to use the complete authentication (that is, the typed signature of the adjutant in the lower right hand section of the page under the order or command line; the word "Official," followed by the adjutant's signature over his typed name, grade, arm or service, and title):

On a letter, the adjutant's name and signature should appear only once, in the lower right-hand section under the order line.

On informal memorandums addressed to individuals, the same as on letters.

On more formal communications—orders, numbered memorandums, training memorandums—the same type of authentication as is used on orders.

On daily bulletins, the general practice is to authenticate in the same manner as on letters.

On informal "buck slips" the adjutant usually initials the buck slip, or he may use a rubber stamp containing his name, rank, arm or service, and title and initial above the rubber stamp.

HEADQUARTERS 100th INFANTRY

FORT DIX, N. J.
May 1, 1941

GENERAL ORDERS
No. 1

I. Activation of 100th Infantry.—Pursuant to directive contained in section II, paragraph 1, General Orders No. 2, Headquarters 20th Infantry Division, Fort Dix, N.J., May 1, 1941, the 100th Infantry less 3d Battalion, is activated at 12:01 a.m., May 1, 1941.

II. Assumption of command.—Pursuant to directive contained in paragraph 6, Special Orders No. 1, Headquarters 20th Infantry Division, Fort Dix, N.J., May 1, 1941, the undersigned hereby assumes command of the 100th Infantry.

III. Appointment of staff.—The following appointments to the staff, this headquarters, are announced:

Adjutant. (S-1) Captain THOMAS A. DuBOIS (0-000-000), 100th Infantry.
Intelligence Officer. (S-2) Captain RICHARD C. GLEAVE (0-000000), 100th Infantry.
Plans and Training Officer. (S-3) Major RALPH S. EASONS (0-000000), 100th Infantry.
Supply Officer. (S-4) Major ROBERT T. JONES (0-000-000), 100th Infantry, in addition to other duties.

/s/ *John O. Atwater*
/t/ JOHN O. ATWATER
Colonel, 100th Infantry
Commanding

HEADQUARTERS 100th INFANTRY

FORT DIX, N. J.
May 1, 1941

SPECIAL ORDERS
No. 1

1. Major ROBERT T. JONES (0-000000), S-4 100th Infantry, is assigned as Commanding Officer, Service Company.

2. The following-named officers, having reported for duty, are assigned to the Service Company:

(Here list them by grade, name, serial number, in order of rank.)

3. The following-named enlisted men, having reported for duty, are assigned to the Service Company:

(List them by grade, name, serial number, in order of rank.)

4. Captain JAMES M. PERKINS (0-000000), 100th Infantry, is detailed as Assistant Adjutant, this headquarters, and will report to the Adjutant for instructions.

5. Captain GEORGE SHOTWELL (0-000000), Service Company, 100th Infantry, is designated as munitions officer.

By order of Colonel ATWATER:

(Typed) Thomas A. DuBois
Captain, 100th Infantry
Adjutant

Official:
/s/ *Thomas A. DuBois*
/t/ Thomas A. DuBois
Captain, 100th Infantry
Adjutant

V REPORTS (A specimen)[4]

FORT DIX, NEW JERSEY

July 11, 1941

SUBJECT: Report of Investigation, motor vehicle accident.

TO: The Commanding Officer, 100th Infantry, Fort Dix, N. J.

[4] TM 12-250, p. 286

1. In compliance with 1st indorsement, Headquarters 100th Infantry, July 10, 1941, submitted herewith is report of investigation of a motor vehicle accident involving Government-owned vehicle, Chevrolet truck No. 94487, assigned to Company C, 100th Infantry, and a privately owned motor vehicle owned by Mr. Willis R. Macy of Camden, New Jersey, and driven by Mr. Willis R. Macy, Camden, New Jersey, which occurred at about 4:10 P.M. on July 9, 1941, on Highway No. 130 at a point about five miles north of Camden, New Jersey.

2. This investigation includes the following documentary evidence with Exhibits A to F, each in quadruplicate:

Driver's report of accident, Form No. 26
Investigating officer's report, Form No. 27
Statement of Pvt. Willie D. Killen. Exhibit "A"
Statement of Sergeant John L. Martin. Exhibit "B"
Statement of Captain Paul M. Knight, 100th Inf. Exhibit "C"
Statement of 1st Lt. James A. Kilpatrick, M.C. Exhibit "D"
Statement of Mr. Willis R. Macy. Exhibit "E"
Statement of Nicholas F. Carter, Major, Q.M.C., Division Motor Transport Officer. Exhibit "F"

3. FACTS:

The Government-owned motor vehicle, Chevrolet truck No. 94487, was proceeding on official business from Company C, 100th Infantry, Fort Dix, New Jersey, to Camden, New Jersey, on July 9, 1941, at or about 4:10 P.M. when at a point on Highway No. 130 about five miles north of Camden, New Jersey, it collided with privately owned motor vehicle owned by Mr. Willis R. Macy of Camden, New Jersey, and driven by Mr. Willis R. Macy of Camden, New Jersey. The Government motor vehicle was driven by Private Willie D. Killen, 8442724, Company C, 100th Infantry, 20th Division, Fort Dix, New Jersey.

4. FINDINGS:

a. The accident occurred as stated above.

b. Weather conditions were sunny and clear.

c. The driver of Government truck No. 94487 was not under the influence of alcohol or narcotics.

d. The driver of the privately owned motor vehicle was not under the influence of alcohol or narcotics.

e. The brakes on Government truck No. 94487 were in good condition and were operating properly.

f. The lights on Government truck No. 94487 were in good condition and were operating properly.

g. The brakes on the privately owned motor vehicle were in good condition and operating properly.

h. The lights on the privately owned motor vehicle were in good condition and operating properly.

i. The speed of Government truck No. 94487 just before the time of the accident was about 30 miles per hour and at the time of accident the forward motion of Government truck had practically ceased. (See Exhibit "A," Statement of Driver.)

j. The speed of the privately owned vehicle at the time of the accident was 10 miles per hour. (See Exhibit "A" and "E," Statement of Driver and Mr. Willis R. Macy.)

k. The accident was caused by no fault or neglect of the driver of Government motor vehicle. From statement of witnesses the driver of Government truck No. 94487 was over on extreme right of road and the driver of the civilian owned automobile was not on his side of the road; thus the civilian owned automobile struck Government truck No. 94487.

l. The accident was caused wholly or in part by the negligence of the driver of the privately owned vehicle (see Exhibits "A," "B," and "E," Statements of Witnesses).

m. The damage to Government truck No. 94487 was as follows: Crushed right headlight assembly, damaged radiator grill, crushed near fender. The cost of repairs to Government truck No. 94487 is eighteen dollars and thirty-nine cents ($18.39) (see Exhibit "F," Statement of Division Motor Transport Officer).

n. The damage to the privately owned vehicle was nothing. (See Exhibit "E" statement of Mr. Willis R. Macy.)

5. RECOMMENDATIONS:

a. That Private Willie D. Killen (8442724) be not held pecuniarily liable for the cost of repairs to Government motor vehicle.

b. That the Government motor vehicle, Chevrolet 1½-ton truck No. 94487, be repaired at Government expense at the Quartermaster Motor Repair Shop and returned to service.

c. That the responsible officer, Captain Paul M. Knight, 100th Infantry, submit a Report of Survey (A.G.O. Form No. 15) concerning damaged parts of the Government motor vehicle.

d. That the Government enter a claim against Mr. Willis R. Macy, 462 Elwin Street, Camden, New Jersey, for $18.39 representing the cost of repairs to Government motor vehicle, Chevrolet 1½-ton truck No. 94487.

/s/ *Edward J. Day*

EDWARD J. DAY
1st Lieutenant, 100th Infantry
Investigating Officer

United States Navy Regulations

The following brief extracts are taken from the *United States Navy Regulations.*[5]

I GENERAL CORRESPONDENCE

1. Correspondence embraces letters, messages, reports, and similar matter.

2. Officers shall endeavor to use accuracy, simplicity, and conciseness in official correspondence, confining themselves to the subject at hand without omitting essential details and arranging paragraphs of letters in logical sequence.

3. Tables, diagrams, and sketches shall be used, if practicable, when they add to clearness.

4. All official communications intended for officers holding positions with recognized titles shall be addressed to them by title and not by name, as:

The Secretary of the Navy.
The Chief of the Bureau of Navigation.
The Commandant.
The Commander in Chief, ——— Fleet (or Squadron).
The Commander ——— Squadron (or Division).
The Commanding Officer.

5. The practice of addressing communications, except encrypted messages, to "The Navy Department" or to "The Navy Department (———)" is prohibited. The following are cited as authorized addressees:

The Secretary of the Navy.
The Assistant Secretary of the Navy.
The Chief of Naval Operations.
The Chairman of the General Board.
The Chief of the Bureau of ———.
The Major General Commandant, Marine Corps.
The Judge Advocate General.
The Chief Clerk of the Navy Department.

6. All correspondence shall be typewritten if practicable, but should a typewriter be unavailable, the communication must be legibly written. It must not have erasures or interlineations.

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[5] The *United States Navy Regulations*, 1920. Reprinted, 1941, with all changes up to and including No. 22.

7. A sufficient number of copies of letters and endorsements shall be made for the files or other purposes. Each carbon copy shall show the office of origin. The name of the signing officer shall be typewritten or stamped on all copies.

8. In preparing letters, endorsements, and reports which go through another office or other offices, the office preparing the original will make on thin white paper a copy for each office through which the correspondence is to pass before it reaches its final destination. This copy will be marked for the appropriate office.

9. Every person in the Navy making an official communication of any kind to any superior authority, other than his immediate commanding officer (except as provided for in art. 2038, par. 2), shall send the same unsealed to his commanding officer, to be by him remarked upon and forwarded.

10. As a general rule, a letter shall be answered by a separate letter and not by endorsement.

11. Separate letters shall be written on separate subjects unless the subjects are of like nature. In submitting reports or recommendations relative to repairs, alterations, etc., each vessel will be treated in separate correspondence.

II FORMS OF CORRESPONDENCE

1. For official correspondence in the Navy, whether letters or endorsements, letter paper shall habitually be used. For the original, or first copy, it shall be white typewriter paper 8 by 10½ inches in size of substance No. 32 or substance No. 40. For file copies, a green-tinted paper of the same size of substance No. 26. For additional carbon copies, thin paper other than green shall be used. When the highest degree of permanency is required, as in records of court-martial proceedings, 75 per cent rag, bond, white paper shall be used. For general correspondence 25 per cent rag, bond, white paper is prescribed.

2. Typewriter cap, used only in special cases, shall be 8 by 13 inches in size, but otherwise similar to letter paper.

3. The sheets of a letter or report shall be arranged in regular order from bottom to top; i.e., the first sheet on the bottom, the last sheet on top.

Enclosures, if any, shall be attached in regular order on bottom of the letter, all securely fastened together, the head of the fastener

underneath, and the ends turned over the face of the correspondence in order that the last sheet may be readily removed to place endorsements thereon.

4. When folding is necessary, letter paper shall be folded in three equal folds parallel to the writing. Typewriter cap shall be folded in four equal folds parallel to the writing.

5. Letters shall begin with the ship or station, place, and date, grouped and spaced as indicated in the example in paragraph 27 (see No. 18 here). The upper line of the heading shall be at least 1½ inches from the top of the page.

In the case of endorsements which start on a new page or any letter or endorsement continued on a new page there shall also be left clear at least 1½ inches at the top for binding purposes.

6. Following the heading and date in letters and endorsements, either the official designation, or the name and rank of the writer preceded by the word "From," shall be written at the left side of the page as indicated in example in paragraph 27 (see No. 18 here).

7. On the line below "From," and preceded by "To" at the left of the page, shall appear the official designation of the official addressed; following this the channel through which the communication is to pass; these offices to be designated by numerals indicating the sequence of routing.

8. Following the address, the subject of the correspondence, briefed, shall be written across the page, preceded by the word "Subject."

9. The brief of the subject should be written in about the same form and terms as would be used in indexing the communication in filing; for example "Office labor-saving devices for patrol squadrons; cognizance of."

10. In acknowledging, answering, or referring to official communications, the file number (letters as well as figures), and date shall be included in the "Reference." References shall be lettered in small letters and may be referred to in the communication as "Reference (a)," etc.

11. The file number of the letter or endorsement shall be placed in the upper left corner, about 1 inch from top and 1 inch from the left edge of the page; the abbreviation or initials of the section

or division preparing the correspondence to follow on the same line as the file number.

12. The body of letters and endorsements shall be written single spaced, with one double space between paragraphs. Each endorsement shall, where possible, be written on the same sheet as the preceding letter or endorsement, with a space of about one-half inch intervening.

13. Paragraphs in letters and endorsements, or other official papers, shall be numbered. Subparagraphs shall be lettered thus: (a), (b), etc.

14. The body of the letter shall begin and end without any ceremonial form or expression, such as "Sir," "I have the honor to report," "Very respectfully," etc., and shall be followed by the signature of the writer without designation of his rank, title, or office.

15. In the body of the letter U. S. Navy shall be abbreviated to U. S. N., U. S. Naval Reserve to U. S. N. R., U. S. Marine Corps to U. S. M. C., and U. S. Marine Corps Reserve to U. S. M. C. R. In the case of names of officers of the Staff Corps the designations as given in article 148 shall be abbreviated as follows: Medical Corps to M. C., Supply Corps to S. C., Dental Corps to D. C., Construction Corps to C. C., Civil Engineer Corps to C. E. C., Chaplain Corps to Ch. C.

16. Endorsements, whether written or stamped, except those referred to in the next paragraph, shall be placed in regular order, beginning on the last page of the letter, immediately below the signature, if there be room there; if not, additional full sized sheets shall be appended to the letter to accommodate them. Each endorsement except an endorsement on orders shall include, identification of the basic correspondence as shown in the example in paragraph 27. Endorsement slips shall not be used except on correspondence with other departments which use endorsement slips.

17. Only one page of the sheet shall be written upon, and a margin of 1 inch shall be left on each side and at the bottom of the sheet. In preparing short letters not requiring endorsements such letters should be so centered on the page as to present a well-balanced appearance.

18. The following is an example of correct form of correspondence.

File No.

U. S. S. ....
Passage .... to ....
February 1, 1939.

From: (10 spaces) ....
To: ....

Via: ....

Subject: ....

References: (a) ....
(b) ....

Enclosure: (A) ....

1. ....
....

2. ....
....

Signature ....

1st Endorsement

on .... File No.
dated Feb. 1, 1939.

File No. ....
....
....

From: ....
To: ....

Subject ....
1. ....

Signature ....

19. Letters addressed to officials and others who have not adopted the form of correspondence described in article 2043 shall be prepared in the customary form as indicated in the following example. If endorsements become necessary in this class of correspondence, they shall be prepared in the manner prescribed in article 2043; also, references and enclosures shall be as indicated in that article.

File No.

U. S. S. TEXAS
U. S. Navy Yard, New York,
March 1, 1938.

Sir:

....
....
....
....
....

....
....
....
....
....
....

Respectfully,

E. F. ....,
Captain, U. S. Navy.

The American Consul,
Kingston, Jamaica.

Department of State

For detailed instructions about all matters of style, every member of the Department would naturally refer to the 375-page *Style Manual*, with its six main divisions—Office Procedure; Forms of Address, Salutation, and Complimentary Close; Typographic Style; Rhetorical Style; General Information; and Sample Forms. Excerpted here as probably offering to the student of

Governmental usages practical suggestions for purposes of discussion are seven brief sections from the chapter on Rhetorical Style and one Sample Form. It will be observed that the Department of State adheres to the traditional form of indentation and close punctuation. All of the sample forms in the *Manual* concern the correspondence of persons of high position. The one form that is here reproduced is intended solely, therefore, to represent approved usage in the manner of mechanical details.[6]

I GENERAL STYLE

1. The correspondence of the Department of State is written in either the first person or the third person. Where the third person is used, it should be used consistently throughout the entire communication. (For the designations of diplomatic correspondence, see pt. I, pars. 3-9.)

2. A simple, direct style is the most forceful, the most easily understood, and therefore the best. Needless details, needless repetition, and the undue use of adjectives and adverbs should be avoided, as well as the too frequent use of clauses when phrases or words would suffice.

3. In order to avoid a monotonous style, sentence structure should be more or less varied. This may be achieved by inversion of the elements, by beginning the sentences with different parts of speech, and by interspersing short sentences among the longer ones.

4. In order to preserve unity:

   (a) A sentence should contain only one main idea;
   (b) A paragraph should relate to only one main topic or one phase of a subject;
   (c) A composition of any nature should deal with only one main subject.

5. An official communication should be limited to one subject not only for the sake of unity but also for the simplification of indexing.

6. Colloquialisms, slang, and commercial expressions are not appropriate in diplomatic correspondence or formal State papers. (See also pars. 52 and 54.)

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[6] For additional specific regulations the student is referred to *Foreign Service Regulations of the United States of America* (Washington, 1941), Chapter VI, especially Section VI-1, Note 22 and Section VI-2, Notes 1, 2, 4, 9, 12, 13, 14 (Reports, and to *Consular Regulations—Correspondence and Reports*).

II EXPRESSIONS TO BE AVOIDED

The following expressions, which are redundant, overused, or colloquial, should preferably be avoided in the correspondence of the Department of State.

As stated
As you of course know
Assurances are given
Consideration is being given
Contents noted

I am pleased to say I can say I may say I have pleasure in saying I have to advise you I will say I wish to say I would say In reply I would state It may be stated that	Such introductory phrases may be omitted entirely.

Our Mr. Jones
Please. *Preferred:* Will you please
Please find enclosed. *Preferred:* I enclose

Responding(ent) to your letter of Responsive to your letter of	*Preferred:* Replying to your letter of

Same, the same (see p. 257)
Thanking you, I remain
You are informed that
Your favor
Your letter at hand
Your letter of even date

Secretary of State Hull. *Preferred:* Mr. Hull, Secretary of State
Secretary of the Treasury Morgenthau
Ambassador Gibson
Chargé Jones *or* Chargé d'Affaires Jones
Consul Robertson

III SAMPLE FORMS

One of the sample forms is reprinted here for study.

No. 11

The Secretary of State to the President (Informal)

(Written on blue-seal paper 8 x 10½ inches)

Address official communication to
THE SECRETARY OF STATE
Washington, D. C.

(SEAL)

DEPARTMENT OF STATE
Washington
September 18, 1935

My dear Mr. President:

This government has received an invitation, through the Greek Legation at Washington, to be officially represented at the First Inter-Balkan Conference for the Protection of Children, to be held at Athens, Greece, October 20 to 26, 1935.

The Departments of the Treasury, Interior, and Labor have recommended that the invitation be accepted, and Dr. Homer W. Davis, President of Athens College, Athens, has been suggested as a delegate.

Will you kindly inform me whether the designation of Dr. Davis as an official delegate would meet with your approval.

Faithfully yours,

Cordell Hull

The President,
The White House.

IV CONSULAR REGULATIONS
CORRESPONDENCE AND REPORTS

Extracts from
Form and Transmission of Correspondence and Reports

Sec. 122

1 Consular officers should insist on careful typography, neat appearance, and orderly arrangement.

2 Language must be grammatical, dignified, and conservative.

3 The first personal pronoun should be used sparingly, and the neuter gender used when referring to vessels and countries.

4 Abbreviations should be avoided except in quotations.

5 When foreign names, words, or phrases occur, care should be taken that the foreign spelling should be accurately followed and the proper accents or diacritical marks shown.

6 Each dispatch should be confined to one subject. Precise references should be made in the opening sentence of the dispatch.

7 All copies of reports, including originals, should be typewritten and double spaced. The margin should be 1½ inches on the left- and right-hand sides of the page, 1 inch at the bottom, and 1½ inches at the top of second and subsequent sheets.

8 The following form of title is established.

____

(Title)

From (Pen signature on original)

____

(Officer's name and title) (Typed name on original and all copies)

________________Date of completion______________________
(Office) (Month) (Day) (Year)

Date of mailing________________________
(Month) (Day) (Year)

9 Statistical tables, lists, transactions, quotations, and in general all copied matter should be single spaced.

10 The initials of the author and of the typist should be placed on the final page in the lower left-hand corner.

11 In trade reports, in order to facilitate publication, a separate page should be used for beginning every main topic dealt with.

12 Subheadings and subdivisions should be used.

13 The language of trade reports should be free from all possible ambiguity.

14 All despatches and reports containing quotations from published sources should supply specific information identifying by title, number, date, and place of issue, the publication from which each quotation has been copied or translated.

APPENDIX D

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